MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXXIX. FEBRUARY 8, 1929. No. 4

ANNUAL GENERAL MEETING.

Rev. T. E. R. PHILLIPS, PRESIDENT, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The Report of the Auditors of the Treasurer's accounts for the year 1928 was read, and is given on p. 291.

The Annual Report of the Council was partly read.

The Address was delivered by the President, after which the Gold Medal was handed to Professor Ejnar Hertzsprung, to whom it had been awarded for his Determination of the Distance of the Lesser Magellanic Cloud, and other pioneering work in stellar astronomy (see p. 404).

The President announced that Professor Hertzsprung had been appointed George Darwin Lecturer for 1929, and that the lecture would be delivered at the May meeting of the Society.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 420.

During an interval, Commander R. T. Gould gave an address on Harrison and his Timekeepers, illustrated by lantern slides. Commander Gould had recently overhauled the Harrison Clock belonging to the Society, and a note by him on this work appears on p. 398.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

The election by the Council of the following Fellows was duly confirmed :—

The Rev. William Ira Brown, Rishton Vicarage, Blackburn, Lancs;
Arthur Kington Chapman, Ellerslie, Auchenflower, Queensland, Australia;
Egbert Adriaan Kreiken, Ph.D., Bosscha-Sterrewacht, Lembang, Java, Dutch East Indies;
Stavros Plakidis, National Observatory, Athens;
John Herbert Hedley Robinson, 17 Elmgrove Road, Cotham, Bristol;
Harlan T. Stetson, Professor of Astronomy, Harvard University, Cambridge, Mass., U.S.A.;
Reginald Owen Street, M.A., M.Sc., The University, Liverpool;
R. v. d. R. Woolley, B.A., Gonville and Caius College, Cambridge; and
Herman Zanstra, Ph.D., Imperial College of Science and Technology, London, S.W. 7.

Report of the Council to the Hundred and Ninth Annual General Meeting of the Society.

Progress and Present State of the Society.

	Patron	Institutional Members	Honorary Member	Fellows		Associates	Total
				Compounders	Annual Subscribers		
1927 December 31	1	2	1	222	698	48	972
Since elected	...	...	...	+1	+41	+3	...
Deceased	...	...	...	−8	−16	−2	...
Resigned	...	...	...	...	−22	...	...
Since compounded	...	...	...	+7	− 7	...	...
Removed from list	...	...	...	...	−14	...	...
1928 December 31	1	2	1	222	680	49	955

(Six Associates are also Fellows, and are therefore counted twice in the above table.)

Dr. Knobel's Cash Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Balances, 1928 January 1:—		
In hand of Assistant Secretary on Petty Cash Account	34 15 9	
At Bankers', on Current Account	383 15 5	
At Bankers', on Deposit Account (including Special Fund, £215, 12s. 5d.)	391 3 0	
At Bankers', on "C" Account (Trust Funds) ...	148 12 0	
		958 6 2
Received on account of Dividends:—		
£1250 Metropolitan 3-per-cent. Stock (Tax free) ...	37 10 0	
£2000 Swansea Corporation 3½-per-cent. Stock (Tax free)	70 0 0	
£2287, 6s. 9d. East Indian Railway 3-per-cent. Stock (Tax free)	54 17 10	
£5125 London, Midland and Scottish Railway 4-per-cent. Debenture Stock	164 0 0	
£750 London, Midland and Scottish Railway 4-per-cent. Consolidated Preference Stock	24 0 0	
£2400 Gas Light & Coke Co. 3-per-cent. Debenture Stock	57 12 0	
£2000 Commercial Gas Co. 3-per-cent. Debenture Stock	48 0 0	
£3852, 12s. 6d. War Loan Inscribed 5-per-cent. Stock (Tax free)	192 12 6	
£500 National War Bonds, 1929 (Tax free)	25 0 0	
£419, 17s. 11d. Conversion Loan 4½-per-cent. Stock, 1940/44	15 2 4	
£695, 16s. Conversion Loan 3½-per-cent. Stock, 1961	19 9 8	
Interest on Deposit Account	9 16 0	
	718 0 4	
Sale of Publications:—		
At Society's Rooms £17 7 9		
At Wheldon & Wesley's 280 19 7		
Reprints 97 19 0		
	396 6 4	
Sale of Photographs	68 19 0	
Miscellaneous Receipts:—		
London Mathematical Society, expenses of Meetings, etc. £30 0 0		
Assistant Secretary and Clerk, Pension Premiums 19 5 0		
Postages, etc., repaid 4 2 9		
Use of Telephone 0 2 9		
Sale of Waste Paper 0 5 0		
	53 15 6	
		1237 1 2
Received on account of Subscriptions:—		
603½ Annual Contributions for 1928 (including 2 Institutional Membership fees)	1267 7 0	
23½ Annual Contributions, 1929–31, paid in advance	49 7 0	
48 Admission Fees (including 7 due in 1927)	100 16 0	
47 First Contributions (including 7 due in 1927) ...	85 1 0	
Arrears paid off:—		
6 for 1925 ... ... 12 12 0		
30 for 1926 (plus 2s.) 63 2 0		
76 for 1927 ... ... 159 12 0		
	235 6 0	
		1737 17 0
Compositions		113 8 0
Trust Fund Dividends:—		
£1212, 13s. 3d. East Indian Railway 3-per-cent. Debenture Stock	29 2 2	
£542, 18s. 2d. India 3½-per-cent. Stock (Tax free) ...	19 0 0	
£1934, 10s. 2d. 5-per-cent. War Stock, 1929/47 (Tax free)	96 14 6	
		144 16 8
Special Fund: Donation		0 16 10
		£4192 5 10

Examined and found correct.

(Signed) C. O. BARTRUM.

1929 *January* 19. T. WHITWELL.

Astronomical Society, from 1928 *January* 1 *to December* 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	245	16	8			
Clerk: Salary	160	0	0			
Assistant Secretary and Clerk for work done for London Mathematical Society in 1927	10	0	0			
Pension Premiums for Assistant Secretary and Clerk ...	57	15	0			
Grant to Assistant Secretary	25	0	0			
Porter and Wife: Wages	144	13	0			
Health and Unemployment Insurance	6	15	2			
Pensions, J. and Mrs. Barrett	48	15	0			
				698	14	10
Licence for Porter	0	15	0			
Fire and Accident Insurance	15	13	5			
Telephone	13	3	7			
Registration of Telegraphic Address	2	0	0			
Time Signal	5	2	8			
Water Rate, 1927–1928	20	9	6			
				57	4	2
Postage and Packing (including postage of *Monthly Notices*, etc., £83, 4s. 2d.)				127	1	1
Printing, etc.:—						
Monthly Notices (Vol. 88, Nos. 1–9)	907	3	7			
Geophysical Supplements (Vol. 1, No. 10; Vol. 2, Nos. 1, 2)	219	4	2			
Bye-laws, 1928	19	14	10			
Reprints	113	18	6			
Miscellaneous	73	0	8			
Photo-engraving:—						
Monthly Notices £42 11 4						
Geophysical Supplements 11 12 10						
	54	4	2			
				1387	5	11
Reproduction of Photographs for sale				92	15	7
Library Equipment	4	1	6			
Stationery and Office Expenses	15	3	0			
Coal, Gas, Electric Light, Firewood	76	13	11			
House Cleaning and Laundry	22	7	3			
Hire of Cinema for George Darwin Lecture	2	2	0			
Miscellaneous Expenditure	9	7	5			
Lantern, with Stand and Screen, and re-wiring for same	69	18	3			
Bookshelves in New Library	112	0	0			
Redecorating Meeting Room	138	18	5			
Fittings and Repairs	52	9	8			
Repair of Harrison Clock to date	33	14	6			
Expenses of R.A.S. Meetings	19	6	7			
Expenses of Geophysical Meetings	8	0	11			
Expenses of L.M.S. Meetings	6	0	0			
				570	3	5
Bank Charges and Cheque-Book				1	7	4
				2934	12	4
Expenditure on Trust Accounts:—						
George Darwin Lecture	49	8	2			
Turnor and Horrocks Fund } Library	12	14	5			
Harry Watson Fund ... } Library	50	12	6			
Lee and Janson Fund	10	0	0			
Jackson-Gwilt Fund	62	12	6			
				185	7	7
Balances, 1928 December 31:—						
In hand of Assistant Secretary on Petty Cash Account	17	12	7			
At Bankers', on Current Account ... £542 16 9						
Add Due from "C" Account ... 12 12 6						
	555	9	3			
At Bankers', on Deposit Account (including Special Fund, £215, 12s. 5d.)	391	3	0			
At Bankers', on "C" Account (Trust Funds) £120 13 7						
Deduct Due to General Account ... 12 12 6						
	108	1	1			
				1072	5	11
				£4192	5	10

REVENUE

	£	s.	d.	£	s.	d.
To General Expenditure as per Cash Account	2934	12	4			
,, Reserve for Accounts due but not presented	255	0	0			
	3189	12	4			
Less Reserve for Accounts due 1927 now written back	240	0	0			
				2949	12	4
,, 36½ Annual Contributions in Arrear written off ...	76	13	0			
,, 19 Annual Contributions 1928 written off as per contra	39	18	0			
				116	11	0
,, Due for Publications, 1925–1927, but unpaid, and now written off				3	6	0
Excess of Income over Expenditure, 1928				25	17	0
				£3095	6	4

Examined and found correct.

(Signed) C. O. Bartrum.
T. Whitwell.

1929 *January* 19.

ACCOUNT, 1928.

		£	s.	d.	£	s.	d.
By Subscriptions—							
603½	Annual Contributions for 1928 (including 4 from Fellows elected 1928 January, and 2 Institutional Membership Fees)	1267	7	0			
8½	ditto, paid in advance in 1927, and now matured	17	17	0			
61	ditto, outstanding	128	2	0			
19	Contributions for 1928 due, but unpaid, in respect of Fellows died, resigned, or names removed, and written off per contra ...	39	18	0			
692					1453	4	0
,, 34	First Contributions, 1928, at 2 guineas ...	71	8	0			
6	ditto, at 1 guinea	6	6	0			
1	ditto, outstanding	1	1	0			
41					78	15	0
,, 41	Admission Fees, 1928	86	2	0			
1	ditto, outstanding	2	2	0			
42					88	4	0
,, 1	Composition Fee (initial)	31	10	0			
7	ditto, since compounded	81	18	0			
8					113	8	0
,, Sundry Debtors, 1928		...		...	69	12	3
,, Dividends, Sales of Publications and Photographs, and Miscellaneous Receipts, as per Cash Account		1237	1	2			
Less Payments due 1922-27 (£47, 9s. 2d., *less* £3, 6s., 0d. written off, and £3, 9s. 9d. still outstanding)		40	13	5			
					1196	7	9
,, Income Tax (General Fund) deducted—							
1928 January to April		38	9	0			
1928 April to December		57	6	4			
					95	15	4
					£3095	6	4

BALANCE SHEET,

LIABILITIES.

	£	s.	d.	£	s.	d.
20 Subscriptions 1929, paid in 1928	42	0	0			
2½ Subscriptions 1930, paid in 1928	5	5	0			
1 Subscription 1931, paid in 1928	2	2	0			
				49	7	0
Sundry Creditors for Accounts due but not presented ...				255	0	0
Cash Balances (Income) of Trust Funds—						
Turnor and Horrocks Fund	3	3	5			
Harry Watson Fund	44	7	4			
Lee and Janson Fund	22	14	8			
Hannah Jackson Fund	13	1	7			
George Darwin Lectureship Fund	24	14	1			
				108	1	1
Trust Funds (Capital), as per contra				2,949	17	0
Special Fund—						
As at 1927 December 31	1,671	17	8			
Donation in 1928	0	16	10			
				1,672	14	6
Income Tax not yet received, attributable as per contra—						
To Special Fund, 1926, 1927				5	13	3
To Trust Funds, 1926, 1927, 1928				20	0	1
General Fund—As at 1927 December 31	15,873	4	4			
Add—Excess of Income over Expenditure, 1928 ...	25	17	0			
				15,899	1	4
				£20,959	14	3

222 Compounders.

Examined and found correct.

(Signed) C. O. BARTRUM.

T. WHITWELL.

1929 *January* 19.

1928 *December* 31.

ASSETS.

	£ s. d.	£ s. d.
Sundry Debtors for Subscriptions in Arrears—		
14 for 1927	29 8 0	
61 for 1928	128 2 0	
1 First Contribution 1928, outstanding	1 1 0	
1 Admission Fee 1928, outstanding	2 2 0	
		160 13 0
Sundry Debtors, 1927		3 9 9
Sundry Debtors, 1928—		
Due for Publications and Reprints	8 15 6	
Due from Wheldon & Wesley for Publications sold during the last quarter of 1928	60 13 3	
Due for Postages and Packing	0 3 6	
		69 12 3
Investments, General Fund, valued as on 1922 December 29		14,986 0 0
Investments of Special Fund, valued as at date of purchase		1,456 5 3
Investments of Trust Funds, valued as on 1922 December 29 or date of purchase if later		2,949 17 0
Income Tax 1926, 1927, not yet refunded—		
General Fund £140 2 5		
Special Fund 5 13 3		
Trust Funds 12 14 7		
	158 10 3	
Ditto, 1928, outstanding—		
General Fund £95 15 4		
Trust Funds 7 5 6		
	103 0 10	
		261 11 1
Sundry Balances—		
Cash at Bank on Current Account ... £542 16 9		
Add Due from "C" Account 12 12 6		
	555 9 3	
Cash at Bank on Deposit (including Special Fund, £215, 12s. 5d.)	391 3 0	
,, ,, "C" Account (Trust Funds)... ... ... £120 13 7		
Deduct Due to General Account ... 12 12 6		
	108 1 1	
Cash in hand of Assistant Secretary	17 12 7	
		1,072 5 11
		£20,959 14 3

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

Two Gold Medals.

Five Bronze (Jackson-Gwilt) Medals.

INVESTMENTS.

As at 1928 December 31.

GENERAL FUND.

£1250 Metropolitan 3-per-cent. Stock.

£2000 Swansea Corporation 3½-per-cent. Stock.

£2287, 6s. 9d. East Indian Railway 3-per-cent. Debenture Stock.*

£5125 London, Midland, and Scottish Railway 4 per-cent. Debenture Stock.*

£750 London, Midland, and Scottish Railway 4-per cent. Consolidated Preference Stock.*

£2400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.*

£2000 Commercial Gas Co. 3-per-cent. Debenture Stock.*

£3852, 12s. 6d. 5-per-cent. War Loan Inscribed Stock, 1929–47.

GROVE-HILLS SPECIAL FUND.

£500 National War Bonds, 1929.

£419, 17s. 11d. Conversion Loan 4½-per-cent., 1940/44.*

£695, 16s. Conversion Loan 3½-per-cent., 1961.*

FIVE TRUST FUNDS.

£1212, 13s. 3d. East Indian Railway 3-per-cent. Stock.*

£542, 18s. 2d. India 3½-per-cent. Stock.

£1934, 10s. 2d. 5-per-cent. War Loan Inscribed Stock, 1929–47.

* Taxed at source.

Report of the Auditors for the Year 1928.

We have examined the Treasurer's account of receipts and expenditure, and the Revenue Account and Balance Sheet, for the calendar year 1928, and have certified them to be correct. The investment holdings have been certified by the Bank of England and the Westminster Bank respectively.

The Revenue Account shows a small excess of income over expenditure of about £26. The dividends, amounting to nearly £60, on the investments of the Grove-Hills Special Fund have this year for the first time been credited to the General Revenue Account, as the fund was formed to assist the general purposes of the Society. While this item, together with a substantial reduction in the expenditure on printing, has contributed to the small favourable balance, it should be emphasised that a considerable loss on the year's working would have been shown had credit not been taken for a sum of £95, 15s. 4d. in the hope, not yet abandoned, that this amount of income tax may yet be recoverable. A further amount of some £140 in respect of income tax for earlier years has also been included among the assets in the balance-sheet. Exceptional expenditure has been incurred during the year by the necessity for redecorating the meeting-room, the installation of a new lantern, and the provision of bookshelves in the new library. The death of one of the two pensioners relieves the Society, in a full year, of an annual payment of £39.

The adjustments to the cash balances in hand at the end of 1928 arise from a cheque having been inadvertently drawn on the General Account instead of on the Trust Account.

It may be observed that the receipts from composition fees during the year amounted to £113, 8s. 0d., which has been treated as current revenue. The effect of this practice on the finances of the Society may be gauged by the fact that had the Society received annual subscriptions in respect of its 222 compounders, the corresponding revenue would have amounted to £466, 4s. 0d.

The year has been a record one in the amount of arrears of subscriptions that has been paid up by Fellows. This may probably be attributed to the effect of the alteration of Bye-law 26, under which the names of fourteen Fellows have been removed. A list of the remaining defaulters has been placed on the table, and contains the names of those Fellows who are in arrear for sums that were due at the date of the last Annual General Meeting, with the amount due against each Fellow's name.

The books, instruments, and other effects on the premises of the Society appear to be in satisfactory order. The repairs to the Harrison clock, kindly undertaken by Commander Gould, are nearing completion. The Society has acquired by the bequest of the late Mr. W. J. Thorrowgood an 8-inch refractor by Cooke complete with observatory hut and accessories. The instrument has been lent by the Council to Cambridge

Observatory for an initial period of ten years. The checking of the books on the shelves of the Library with the card catalogue has made substantial progress.

We desire to record our indebtedness to the Assistant Secretary for the facilities that have been accorded to us during the audit.

(Signed) C. O. Bartrum.
T. Whitwell.

1929 *January* 23.

Gifts to the General Funds and Property of the Society.

The John Lee Gift : In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The Knott Gift (1899): Mrs. George Knott presented to the Society the sum of £250, to defray the cost of printing *Memoirs*, vol. lii., containing the late Mr. Knott's Observations of Variable Stars.

The Peek Bequest (1904): Sir C. E. Peek bequeathed to the Society the sum of £200, as a contribution towards the expenses of printing the Rousdon Variable Star Observations (*Memoirs*, vol. lv., part 1).

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

The Brook Gift (1907): C. L. Brook, Esq., gave one-third of the cost of printing Pogson's Variable Star Observations (*Memoirs*, vol. lviii.).

The Gill Bequest (1914): Sir David Gill, K.C.B., F.R.S., bequeathed to the Society the sum of £250, in aid of Astronomical Research, in grateful remembrance of a like sum paid out of the funds of the Society in aid of his expedition to Ascension in the year 1877. In accordance with his wishes this bequest was expended to defray part of the cost of publishing vol. lxiii. of the *Memoirs*, containing the Theory of the Four Great Satellites of Jupiter.

The Parsons Gift (1922): The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2500 War Stock (1929–47), in memory of his father, the 3rd Earl of Rosse, who made the 6-foot Reflector, and who died 1867 October 31.

The Grove-Hills Bequest (1922): Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection of early Astronomical and Mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

The Thorrowgood Bequest (1928): Mr. W. J. Thorrowgood bequeathed to the Society his 8-inch Equatorial Refractor by Cooke (formerly the property of Dr. W. H. Maw), with its observatory hut complete, together with the sum of £100 to cover the cost of removal of the same, all free of legacy duty.

The Grove-Hills Special Fund. In 1923 the then Treasurer, Col. Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. He aimed at securing £1800, and up to the present the total amount received from all sources (including dividends on the investments representing the fund) is £1889, 5*s.* 8*d.*, of which £200 was transferred during 1923 to the General Fund to meet current expenditure, and £1472, 16*s.* 5*d.* was invested, and is now represented by £500 National War Bond 1929, £419, 17*s.* 11*d.* Conversion Loan 4½ per cent. 1940–44, and £695, 16*s.* Conversion Loan 3½ per cent. 1961. In 1928 the Council resolved that the interest on the Special Fund should be regarded as part of the general income of the Society, and no longer funded.

	£	*s.*	*d.*
1928 Jan. 1. Cash Balance of Fund on Deposit ..	215	12	5
1928. Donation (R. De Lury)		16	10
	£216	9	3

	£	*s.*	*d.*
1928. Transfer to General Account		16	10
1928 Dec. 31. Cash Balance of Fund on Deposit ..	215	12	5
	£216	9	3

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1928 Jan. 1. Balance of Fund	24	14	2	1928. Grant from Fund ..	10	0	0
1928. Dividends, East Indian Railway ..	8	0	6	1928 Dec. 31. Balance of Fund	22	14	8
	£32	14	8		£32	14	8

The Turnor Fund and the Horrocks Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks: to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	*s.*	*d.*		£	*s.*	*d.*
1928 Jan. 1. Balance of Fund	2	5	0	1928. Purchase of Books..	12	14	5
1928. Dividends, East Indian Railway ..	13	12	10	1928 Dec. 31. Balance of Fund	3	3	5
	£15	17	10		£15	17	10

The Harry Watson Memorial Fund: In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the Library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s.* 2*d.* India 3½-per-cent. stock. In 1923 Mrs. Watson bequeathed a further sum of £958, 17*s.* 0*d.* to the Society, which now stands invested in £946, 6*s.* 11*d.* 5-per-cent. War Stock 1929–47. The Council resolved that these two sums should together constitute a Trust Fund, to be designated *The Harry Watson Memorial Fund*, to be used for the purchase and binding of books.

	£	*s.*	*d.*		£	*s.*	*d.*
1928 Jan. 1. Balance of Fund	28	13	6	1928. Purchase of Books..	15	4	0
1928. Dividends, India 3½ per cent.	19	0	0	Binding	35	8	6
Dividends, War Stock 5 per cent.	47	6	4	1928 Dec. 31. Balance of Fund	44	7	4
	£94	19	10		£94	19	10

The Hannah Jackson (née Gwilt) Fund : In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6d. East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	*s.*	*d.*		£	*s.*	*d.*
1928 Jan. 1. Balance of Fund	68	5	3	1928. Gifts from Fund ..	50	0	0
1928. Dividends, East Indian Railway ..	7	8	10	Due to General Account, for Medals	12	12	6
				1928 Dec. 31. Balance of Fund	13	1	7
	£75	14	1		£75	14	1

The George Darwin Lectureship Fund : In 1926 June, the then President, Dr. J. H. Jeans, presented to the Society the sum of £1000 for the endowment of an annual lectureship, to be called *The George Darwin Lectureship*, the lecture to be on some subject of interest to astronomers, preference being given, in electing a lecturer, to one normally resident outside the British Isles.

This sum has been invested in £988 3*s.* 3*d.* 5-per-cent. War Stock 1929–47, and the income will be annually applied to the purposes of the Trust in accordance with the terms of the Deed of Gift.

	£	*s.*	*d.*		£	*s.*	*d*
1928 Jan. 1. Balance of Fund	24	14	1	1928 June. Lectureship Fee	49	8	-
1928. Dividends, War Stock 5 per cent. ..	49	8	2	1928 Dec. 31. Balance of Fund	24	14	1
	£74	2	3		£74	2	3

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S. Ref. No.

395. Orion Nebula. (*a*) through æsculine screen, transmitting mainly Hγ, δ, ε, and (*b*) through nickel oxide screen, transmitting λ 3727/9, 1920 December, 30-in. Refl., Exp. 40 min. and 47 min., Reynolds, Helwan.

396. Sunspot Spectrum. Spot approaching W. limb, 1918 December 25, Grating Spectrograph, Evershed.

397. Spectrum of Chromosphere (ultra-violet), 1926 January 14, Stratton and Davidson, Sumatra.

398. Spectrum of Corona (ultra-violet), 1926 January 14, Stratton and Davidson, Sumatra.

399. Jupiter. Exposures in ultra-violet and infra-red light, 1927 October 2, Wright, Lick Observatory.

400. Nubecula Minor, 1898 November 10, 24-in. Bruce doublet, Harvard (Arequipa).

R.A.S. Ref. No.

401. Orion Nebulosities, 1927 January 6, 3-in. lens, F.L. 21-in., Exp. 5 hours, Ross, Yerkes.
402. Andromeda Nebula (Southern portion), 100-in. Refl., Hubble, Mount Wilson.
403. Prominences and Flocculi, Calcium (H), 1913 March 7 (Sunspot Minimum), Evershed.
404. Prominences and Flocculi, Calcium (H), 1918 January 11 (Sunspot Maximum), Evershed.
405. Mars. Exposures in violet and ultra-violet light, showing cloud, 1926 October 14, 15, 16, 18, Wright, Lick Observatory.
406. Mars. Exposures in ultra-violet, green, yellow, red, infra-red, and violet light, 1926 October 16, Wright, Lick Observatory.
407. Mars. Exposures, 1926 November 2, 3, in infra-red, and 1926 November 2, in ultra-violet light, Wright, Lick Observatory.
408. Mars. Exposures in ultra-violet and infra-red light, 1926 November 2, Wright, Lick Observatory.
409. Saturn. Exposures in ultra-violet, violet, yellow, and red light, 1927 July 13, 14, Wright, Lick Observatory.
410. Jupiter. Exposures in ultra-violet, violet, green, yellow, red, and infra-red light, 1927 September 19, Wright, Lick Observatory.
411. Jupiter. Exposures in ultra-violet, violet, green, yellow, red, and infra-red light, 1927 October 2, Wright, Lick Observatory.
412. Venus. Exposures in ultra-violet and infra-red light, 1927 November 23 and December 8, Wright, Lick Observatory.

Publications of the Society.

During the past year the Society has published *Monthly Notices*, vol. lxxxviii., and *Geophysical Supplements*, vol. i., No. 10; vol. ii., Nos. 1, 2.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—William Steadman Aldis.
Thomas William Bush.
William Bladen Croft.
R. A. Craigie Daunt.
Richard Evan Day.
James Whitbread Lee Glaisher.
Hester Periam Hawkins.
Thomas Humphries.
Henry Lloyd Jenkins.
Walter Claude Johnson.
William Redfern Kelly.
Edward Bruce Kirk.
Arthur Herbert Leahy.
Francis P. Leavenworth.
Edward Walter Maunder.
Frank D. G. M. de Miremont.
George Pearson.
Robert Peebles.
Sydney Royston Pike.
William Edward Plummer.
George Augustine Taylor.
*Henry Martyn Taylor.
William John Thorrowgood.
Charles John Wilson.
Associates :—Antonio Abetti.
Pierre Henri Puiseux.

William Steadman Aldis, the second son of the Rev. John Aldis, a well-known Baptist minister, was born on 1839 February 10. He was a member of the noted family of mathematicians which produced five high wranglers. On leaving the City of London School he entered Trinity College Cambridge, where he graduated in 1861 as Senior Wrangler and first Smith's prizeman. He would naturally have been elected a Fellow of his college, more especially as Trinity had not had a Senior Wrangler in the thirteen years 1847-59. But at that time it was still necessary for a Fellow to make a declaration that he was a member of the Church of England. This Aldis refused to do, as had Stirling, afterwards Lord Justice, who was Senior Wrangler in 1860, the first to break the spell of Trinity's lean years. These two cases followed by the conspicuous successes of William Aldis's two younger brothers led to the agitation which achieved the abolition of religious disabilities at both Oxford and Cambridge in 1871.

* Died 1927. Death not reported till 1928.

Mr. Aldis worked as a mathematical coach at Cambridge for several years, during which time he and his wife organised a petition for the admission of women to the examinations and degrees of the University. This petition was widely supported and succeeded in gaining admission for women to the Triposes.

In 1870 Mr. Aldis was appointed Professor of Mathematics in the College of Science, Newcastle-on-Tyne, of which he afterwards became principal. In 1883 he accepted a similar position in Auckland College, New Zealand, which he held till his retirement from active work and return to England in 1896. He published in the *Monthly Notices*, **62**, 633, extensive tables of the function $\frac{1}{2}(\theta + \cos\theta)$, for use in the computation of orbits. His two books, *Solid Geometry* and *Optics*, were for a long time standard works. He was remarkable, apart from his mathematical attainments, for the keen interest he took in social and political reforms. He had a wide circle of friends, who were attracted to him because of his lovable and unselfish disposition, the outcome of a deep religious faith.

Mr. Aldis married in 1863 the eldest daughter of the Rev. William Robinson. He died on 1928 March 7 at the age of eighty-nine, leaving a son and two daughters.

He was elected a Fellow of the Society on 1885 March 13.

Thomas William Bush was born at Nottingham in 1839, and at the time of his death on 1928 April 23 was near his eighty-ninth birthday. His early years were spent amid humble surroundings, but he soon developed a keen desire for knowledge, and made himself proficient in mathematics and optics, whilst also devoting attention to linguistic studies, including German, Greek, Hebrew, and Latin. But practical astronomy became his favourite study, and he was constructing reflecting telescopes, whilst also holding the position of secretary to the Nottingham Hospital. One of his telescopes was shown at one of the national exhibitions, for which he was awarded a gold medal, and thereby introduced to Queen Victoria and Mr. Gladstone, the latter of whom presented him with a spectroscope as a mark of appreciation. His fellow townsmen also presented him with a sidereal clock. After this he was in charge of Lord Forrester's Observatory, at Willey Park, where he made many observations of the planets with an 8-in. refractor. He came to live in the district of East Grinstead in 1909, and whilst there made several 24-in. specula and mountings, one of which was intended for Nottingham University.

He was elected a Fellow of the Society in 1873, resigned in 1900, and was re-elected on 1909 December 10.

W. S. F.

William Bladen Croft was born in London in 1851, and was one of ten children of a doctor practising in the City. He was educated at Christ's Hospital and Pembroke College, Oxford, taking first-class honours in Mathematical Moderations and the Final Schools of Mathematics and Natural Science. He was assistant master at Winchester

College from 1875 to 1915, and was the first regular science master there, his appointment being due to the policy of the headmaster, Dr. Ridding (later Bishop of Southwell), in modernising the school. A mathematician and a physicist, he took a special interest in optical questions, which led to his taking up astronomy. He died at Winchester on 1928 March 23, leaving a widow, three sons, and a daughter.

He was elected a Fellow of the Society on 1891 January 9.

Richard Evan Day, who died on April 2 last at the age of eighty-three, was probably known by few Fellows of the Society, but claims consideration for the fact that he was of the family of Francis Baily, whose memory is revered as that of one of our Founders.

Evan Day was born in London, it is believed at Blackheath, on 1844 November 24, the elder son of John Day, a solicitor, who had married Julia the youngest daughter of John Baily, a doctor of medicine, an elder brother of Francis, to whom the latter bequeathed the greater part of his fortune.

John Day died as the result of an accident when the subject of this note was eleven years old, and his mother took her young family to live on the Continent. Evan therefore went to school at Heidelberg, and afterwards when they returned to England to King Edward's School, Bury St. Edmunds, Suffolk, where his mother settled. From there he passed to Emmanuel College, Cambridge, and qualified for his degree as seventeenth wrangler in the Mathematical Tripos of 1868, the year when Fletcher Moulton, George Darwin, and Christie were at the head of the list. He was an oarsman of skill, and in a letter to the writer, dated 1925 November, he mentioned that three members of the crew of the Emmanuel boat of 1865, then fifth in order on the river, of whom he was one, were still alive. After leaving Cambridge he returned to Heidelberg and studied under Helmholtz. Coming back to England he was for a time a master at Haileybury College, and in 1879 was appointed lecturer in Mathematics in King's College, London.

Whilst in occupation of this post he was engaged in some electrical and magnetic experiments with Professor Grylls Adams, and wrote three text-books for use in the classes. He left King's College in 1893, and after a short period of lecturing at the Birkbeck Institution, spent the remainder of his years at Bromley, Kent, interesting himself in the literature of astronomy and other sciences. He married his first cousin, daughter of a second John Baily, the eldest son of his grandfather John Baily mentioned above, who bore him three sons, all of whom are, or were, officers in the Corps of Royal Engineers. The second of them was killed in France in 1916. Lieutenant-Colonel John Day, R.E., Major Alfred Frank Day, R.E., and an unmarried daughter, survive him. In the year 1910 he came into possession of the Blyford Hall agricultural estate, near Halesworth in Suffolk, and became patron of the living of Blyford in accordance with the terms of the will of his great-uncle, the Rev. Jeremy Day, rector of Hethersett in Norfolk. Though he and Mrs. Day interested themselves in the affairs of their estate, he continued

to live at Bromley until his death, and was buried with Mrs. Day, who predeceased him in 1926, in the churchyard of Blyford.

He was elected a Fellow of the Society on 1889 November 8.

H. P. H.

James Whitbread Lee Glaisher. By the death of our Vice-President, Dr. Glaisher, the Society loses one who served it most devotedly for more than half a century. He was elected a Fellow on 1871 April 14; became a member of the Council three years later, and was re-elected thereon continuously to the end of his life. It is beyond question that he loved his place at our Council table from first to last. He was chosen to succeed Mr. Dunkin as Secretary in 1877, and to fill the Presidential Chair in 1886–1888; and after being many times Vice-President was again elected President in 1901–1903. Others had been more than once President (for the full term) before him: will he be the last of the series? Owing to serious illness he tendered his resignation from the Council at the end of 1927; but the Council refused to accept it, and nominated him Vice-President on the list then in preparation: and the nomination was confirmed by the Society. He was deeply touched by this mark of esteem, and in response made a special effort to be present at a Council meeting at the earliest moment which his convalescence allowed. But this convalescence, which seemed to be progressing favourably, was interrupted by a sudden and serious relapse, and he died, with only a few days' warning, on 1928 December 7. James Whitbread Lee Glaisher was born at Lewisham, Kent, on 1848 November 5. He was the eldest son of James Glaisher, F.R.S. (1809–1904), a Fellow of this Society for sixty-three years, and well known from the balloon ascents which he made with meteorological instruments, in companionship with the aeronaut Mr. Henry Coxwell, who was a working astronomer in early life. The names of Whitbread and Lee given to the son were those of two friends of the father, closely associated with this Society. Moreover, Whitbread, Lee, and Glaisher were the three founders of the Meteorological Society in 1850 (*M.N.*, **40**, 207). S. C. Whitbread, F.R.S. (1796–1879) was Treasurer R.A.S. 1857–1878. Dr. John Lee (1783–1866) was Treasurer 1831–1840, and President 1861–1862. His Presidential address on the second occasion dealt with Argelander's Durchmusterung, but he refused to enter upon the main topic until he had paid a tribute of admiration to the recent "dauntless excursions in the firmament undertaken by our indefatigable colleague, Mr. Glaisher, and his fearless companion Mr. Coxwell."

The son was sent to St. Paul's School, and was always proud to remember that Samuel Pepys and Edmund Halley had been there too. The school lists show that, on 1858 September 17, nine scholars were admitted, the second in order being "James Whitbread Lee Glaisher, aged 9, son of James G., astronomer, Royal Observatory, Greenwich, VIII. 1867," and the eighth being "George Smyth Baden Powell, aged 10, son of Baden P., clergyman, 6 Stanhope Street, Hyde Park, VI. 1864." The latter boy in 1896 took a rather sensational expedition

to Nova Zembla, in his yacht, to see the total eclipse. The yacht ran on a rock, but was got off without serious damage, and the eclipse was well observed by E. J. Stone and W. Shackleton, who got the earliest photograph of the "flash" spectrum. Later the yacht picked up Nansen on his way back from his great Polar expedition. On January 19 of the same year 1858 a single scholar was admitted, viz. "Edwin Ray Lankester, aged 10, son of P. Smith L., physician, 8 Savile Row, Regent Street, VIII. 1864." Sir Ray Lankester, who thus entered St. Paul's in the same year as, but left three years earlier than, Glaisher, kindly tells me that he remembers him at school as "a very amiable and highly gifted mathematician, mainly directed in his studies by his father, who was well known to us all as an aeronaut. Glaisher was liked by everybody, but did nothing remarkable." His name occurs in later lists as having got the Campden Exhibition in 1867 and the Perry Exhibition in 1869. Three years later in each case we find another name honoured in our Society, that of Samuel Arthur Saunder. Lord Campden's exhibitions date back to 1634, and were only tenable at Trinity College, Cambridge. At Glaisher's date they were worth about £80 a year. (A new scheme came into force in 1875.) William Perry, a Fellow of Trinity, who died in 1696, also made his exhibitions attach to Trinity, but they were much smaller in value. Glaisher's name also appears as almost the last "apposer" * of the school in 1881; and he was a Governor from 1885–1909. From St. Paul's Glaisher went, as above implied, to Trinity College, Cambridge, in 1867 October, was elected to a scholarship in 1868, and graduated as second wrangler (Hopkinson being senior) in 1871. In the same year he was elected to a Fellowship and to a Lectureship in Mathematics, an appointment which he held till 1901 by special resolution of the College Council. But in this long period of office no years were more remarkable than the early ones. By the end of 1873 he had published sixty-two papers, and he was made F.R.S. in 1875, before he was twenty-seven years of age. He was associated with the most eminent mathematicians not only on a Committee of the British Association on Mathematical Tables, but in the Editorship of two mathematical journals. And withal he gave excellent lectures in Trinity. "I went to his lectures" (wrote the present Master of Trinity in the *Cambridge Review* for January 25) "when I was an undergraduate, and they were far and away the best courses on Pure Mathematics I ever attended. He was remarkably clear, got over a great deal of ground, was interesting, and infused into his lectures a liveliness which was not characteristic of some of his contemporaries. . . . For example, after talking about some theorem discovered by a mathematician X, he would say: 'It is quite a nice theorem, but X *was* a queer fish: he never met a girl without writing a sonnet to her the next day.' In addition to his work as a lecturer he was very active in encouraging and originating research,

* The first mention of the Apposition was in 1581. "Paid for dinner at the Examination of the Scholars at Candlemas." The Apposition is still maintained as an annual ceremony, but the examinations are now handed over to the Oxford and Cambridge Joint Board.

and the great development of pure mathematics in this University is due in no small degree to the pioneering work which Glaisher began more than fifty years ago."

Another of his former pupils, Professor A. R. Forsyth, has very kindly sent me the following paragraphs specially written for this notice :—

"In the prime of his life, Glaisher was one of the outstanding English pure mathematicians among his contemporaries. He pursued mainly subjects that were well established in the Cambridge course, the principal exception being elliptic functions which, down to the time of his own Tripos, had been unrecognised. His methods of analysis were direct and simple, almost purely algebraical in character : he did not use any of the more modern methods such as those developed from Cauchy, from Riemann, or from Weierstrass. Within the range of his selected subjects and in the use of his methods he was an acknowledged authority.

"The total of his papers is large, being nearly four hundred in number. Many of them are brief, dealing with detailed issues : some are long. A few remain classical : such are his memoir on the combination of observations (in the *Memoirs of the R.A.S.*), his memoir on Riccati's equation (in the *Phil. Trans. of the R.S.*), and a late historical paper on the introduction of the plus and minus signs. The subjects, on which his papers concentrated from time to time, were definite integrals, linear differential equations, elliptic functions, and special numerical functions such as arise in Jacobian q-series. The definite integrals, which chiefly concerned him, were connected with the quarter-periods of elliptic functions. In differential equations he was unrivalled in his own day in the use of symbolical methods developed by Gaskin, Leslie Ellis, and Boole. In elliptic functions his interest centred in the Jacobian theory and, there, specially in q-series : however far he might wander into apparently different regions, somehow many of his investigations would ultimately converge upon the use of those series. In the theory of numbers his principal concern was with particular properties of the resolution of integers into primes. And special mention must be made of the abundant care and time he devoted to the construction of numerical tables of various kinds.

"But it was not solely by his papers that Glaisher influenced mathematics. He was a member of the mathematical staff of Trinity College : as such, his lectures in courses on differential equations, or combination of observations, or elliptic functions, were a revelation to students. In those domains there were no recognised text-books in his earlier days : the examination schedule was not pedantically precise in its indicated range : and these subjects did not fall within the field of applied mathematics, as favoured at Cambridge. So he was free to expound the subjects unfettered : this was done, systematically and continuously. The Tripos was not mentioned. His students were encouraged (then a rare practice) to consult original authorities ; and, under his stimulus, they acquired a working knowledge of a subject without regard to the needs or the subtleties of examinations. The result was that successive bodies of Trinity students came under

Glaisher's inspiring influence. In the course of the years, Cambridge pure mathematics went, in many directions, beyond the sphere of his own activities: such progress was due to men who, frequently, had been his students and had been encouraged by him in their research.

"Glaisher has left a name which, not in one department of human thought alone, stood high in his generation: he has left, also, the memory of a personality of influence upon the men of his time."

A word or two may be added about the two mathematical journals of which he was for many years the sole editor.

The *Quarterly Journal of Mathematics* was started in 1857, and the first fifteen volumes were edited by Sylvester, Ferrers, Stokes, Cayley, and Hermite of Paris. In 1879 Sylvester, Stokes, and Hermite fell out and Glaisher came in. In 1885 Forsyth was added. Then Ferrers, Cayley, and Forsyth successively dropped out in 1893, 1895, 1896, leaving Glaisher alone. The *Messenger of Mathematics* was started in 1862 by the "junior mathematical students of the three universities, Oxford, Cambridge, and Dublin"; but in 1871 a new series was begun with five editors—W. A. Whitworth, C. Taylor, W. J. Lewis, R. Pendlebury, and J. W. L. Glaisher. In 1880 to 1888 the others successively dropped out, again leaving Glaisher in sole charge. The fact that he so remained is partly to be explained by the necessity of a subsidy (since the war) for these unprofitable ventures, which he paid out of his own pocket.

The present generation of astronomers would find many things to interest them in the pages of the *Monthly Notices* in Glaisher's early years of office. Opposite the page recording his election to Council in 1874 (whereon Adams succeeds Cayley as President) are some drawings of Jupiter made with Lord Rosse's 6-foot: and we learn that the drawings had been made possible by the "recent application of clockwork" to the giant telescope: but there is an apologetic mention of an error in labelling the drawings because Sir John Herschel had given in his "Outlines of Astronomy" the figures for mean time rotation, but called them sidereal. We realise that it was before the days not only of the Red Spot (which first appeared in 1878) but of regular ephemerides and clock-driving. Opposite the page on which Glaisher's name first appears as Secretary is a circular from Le Verrier asking for a special search for Vulcan in transit. We seem to be returning to a different world. But the page recording his last election as Secretary in 1883 faces Dr. Common's account of his photograph of the Orion nebula, which brings us nearer modern times. He became Vice-President, and in 1886 succeeded Dunkin as President. The first page of the *Monthly Notices* under his presidency records the success of the Henrys in photographing nebulæ in the Pleiades. His first presidential address, on the award to G. W. Hill, was a masterly summary of the new methods in the Lunar Theory, with an account of the way in which J. C. Adams had been led to work on similar lines. His second address dealt equally well with Auwers's reduction of Bradley's observations. On the third occasion in 1902 he presented the medal to Kapteyn for his Durchmusterung, though it was still a year or two before the great discovery of star-streaming with which we now chiefly

associate the medallist's name, and of which Glaisher would surely have made a brilliant summary. On the fourth occasion Glaisher was prevented from being present, owing to the death of his father a few days earlier; and the address on the work of Hermann Struve, which was read by Professor Turner, owes a great deal to the friendly co-operation of Professor Sampson. Struve's medal was handed to the German Ambassador, Count von Bernstorff, whose name became more widely known later in another connection.

An incident of a quite unusual nature occurred during Glaisher's term as Secretary. Dr. Lee, of whom mention has already been made, had presented the advowsons of the livings of Stone and Hartwell to the Society, but his heir, Mr. E. D. Lee, claimed the advowson of Stone. The Society was advised by Mr. Merriman, a solicitor who took great pains in the matter, that their own claim was valid, and accordingly they proceeded to present the Rev. Mr. Challis (son of Professor Challis of Cambridge) to the living of Stone. But the Bishop of Oxford, embarrassed by the dispute, delayed the "institution" which would have completed the transaction. In the end the Council was compelled to issue a *Quare impedit* writ on the Bishop, lest the presentation should be declared void. The state of affairs was only realised just in time, and owing to a chance meeting of Challis with Glaisher at the seaside: indeed, to issue the writ a meeting of our Council had actually to be called on a Sunday, as the present writer has heard more than once from Glaisher's own lips. In the Council minutes there is no direct record of this Sunday meeting, but the minutes for 1878 November 8 contain the following: "Mr. Merriman was introduced to the Council and explained the circumstances connected with the refusal of the Bishop to institute Mr. Challis. He stated that the *Quare impedit* writ had been served on the Bishop on September 13, and that Mr. Lee had subsequently presented [another clergyman] to the living."

Apparently the decisive action of the Society in issuing the writ produced its effect: on 1878 December 13, "Mr. Merriman reported that Mr. Lee is willing to give the Society £700 for the advowson of the living of Stone and for releasing all claims to the living of Hartwell," and Council accepted the offer on condition that all further opposition to the presentation of Mr. Challis ceased. Glaisher remembered the incident, especially his wholly fortuitous meeting with Mr. Challis, who was amiably letting things slide, and the extraordinary summons for a Sunday meeting of the Council, as a very unusual feature in his career as Secretary, not likely to have many parallels. One constitutional reform of some importance took place during his term of office, and was formally proposed by him. Up to the end of 1881 the Society's publications had been edited by a specially chosen Editor, the last being Professor Cayley. On 1881 December 9 it was proposed by Glaisher and Christie, and unanimously carried, "that the publications of the Society be in future edited by the Secretaries, with such assistance from Mr. Wesley as they may require, and that the sum of £50 per annum, in addition to his ordinary stipend, be paid to him for such services."

The first of Glaisher's contributions to our publications was a long memoir of 50 pages on the "Law of Facility of Errors of Observations and on the Method of Least Squares" (*Mem. R.A.S.*, **39**). It was read on 1872 April 12, just a year after his election as a Fellow, and is a somewhat remarkable early contribution for so young a man. It was inspired by a historical note (by Cleveland Abbe) on the apparently independent publication in 1808 of the Method of Least Squares, by Robert Adrain. He agrees with Abbe that we must "credit Dr. Adrain with the independent invention and application of the most valuable arithmetical process that has been invoked to aid the progress of the exact sciences": but he was disappointed in his expectation of finding new light on the theoretical justification of the principle underlying the use both of the arithmetic mean and least squares. As he put it:

> Although some of the investigations of the law of facility $e^{-h^2x^2}$ are far from rigorous, still there is not one that is not of some importance as throwing additional light on the properties of this law; so that a fresh investigation, and one, moreover, by which the law, not previously known to the author, was discovered, might be expected to be a real addition to, or at all events confirmation of, the known processes.

But he found nothing new of any value, and concluded that Dr. Adrain had "first remarked the convenience of treating equations by the method of least squares, and subsequently endeavoured to justify it by the Theory of Probabilities." The incident is, however, important from having attracted Glaisher's attention to the search for a fundamental proof of the underlying principle, which he conducted with great thoroughness, incidentally rejecting the argument from mere simplicity by quoting an amusing analogy from Professor Tait.

> We might suppose a calculator to insist on gravity varying as the direct distance instead of the inverse square on the ground that the problem of Three Bodies would then become as simple and its solution as exact as they are now complicated and at best only approximate.

But Glaisher did not find any of the proofs satisfactory, and was led to the conclusion that this was only to be expected, since the arithmetic mean does not represent a final solution but only a first approximation. As suggested by De Morgan, the next approximation should be to weight the observations according to their distance from this mean, and solve again: and, if necessary, to make further approximations on these lines. De Morgan's enunciation (*Mem. R.A.S.*, **39**, 103) is for the method of least squares, and is as follows:—

> Assuming the weights as nearly as they can be found, ascertain the most probable result, from which find the weights of the equations. If these agree with the assumed weights the process is finished; if not, repeat the process with the new weights, and so on, until a result is obtained for which the assumed and deduced weights of the equations are sufficiently near to equality.

Glaisher quotes this principle with approval, but the full value of it was only slowly appreciated by him, as is apparent in a subsequent paper "On the Rejection of Discordant Observations" (*M.N.*, **33**, 391), in which he points out that the above method obviates the necessity for rejecting anything: the improved weighting will automatically reduce a discordant observation to insignificance. This led to a brief controversy with E. J. Stone, who had proposed a criterion for rejection. The whole incident has been recalled in some detail, chiefly because it is characteristic of Glaisher's thoroughness in the examination of a scientific question, not only in its theoretical but in its historical aspects, and of his bearing in controversy; and because the principle he advocated seems sound though it has dropped again into the background. He disavows the intention to insist on the continued approximations in every instance: "I make no proposition that observations should always be treated in this manner in practice—the work is sufficiently long as at present—but merely point out that the above is the proper mode of proceeding, if more accuracy be required." The fact that the work is already long (some sets of observations have required many weeks of work to solve the least squares) may, however, be cited as an argument for lengthening it if a better ultimate result can be found. Those who do not know these papers will certainly find them enjoyable reading.

Glaisher also wrote on logarithmic tables, of which he had special knowledge: he had contributed a paper on "Mathematical Tables" to the *Phil. Trans.* before taking his degree, and his report to the British Association in 1873 runs to 174 pages. In the *Monthly Notices* he made an elegant addition to a historic problem which had been revived in 1877 by Bertrand, "on the law of force to any point in the plane of motion in order that the orbit may be always a conic"; which paper was not printed until nearly a year after it had been sketched at the meeting of our Society on 1877 December 14, though an account of it, as given at the meeting, appeared in the first volume of *The Observatory*, and the main result had been set in a question in the Mathematical Tripos for 1878 January 2. Glaisher's keen desire to be complete and accurate sometimes led to these long delays. Perhaps his most valuable contribution to our *Notices* was his account of J. C. Adams, though all his work of that kind was quite first-rate. Adams died on 1892 January 21, and at first Glaisher thought that the notice might be included in the February report: but it soon became clear that more time was needed. The present writer, then Secretary, was, however, scarcely prepared for the difficulty in getting the finished memoir, which was ultimately delivered in MS. on the day when all the rest of the 1893 report had been passed for Press. But it was worth waiting for! Alongside it may be put the great address on Newton, which he delivered (as a substitute for Adams himself) on the occasion of the bicentenary of the *Principia* in the ante-chapel of Trinity College, Cambridge. This was printed in a Cambridge paper provisionally, but Glaisher had the intention of revising it for some scientific publication, adding a copy of the important letter of Newton's,

which he and his father discovered about 1890. Unfortunately, that intention was never carried into effect. Of this address and that on Napier at the tercentenary of the discovery of Logarithms, Sir J. J. Thomson writes that they "have not been excelled as contributions to the early history of mathematics."

Glaisher was a great collector of pottery, china, needlework, old books, valentines, and other things, but especially of pottery. His rooms in Trinity (over the gateway of the famous avenue to "the Backs"), numerous as they were, became crowded with his collection of pottery—tables, walls, cases, even the chairs. It is a remarkable testimony to the devotion of his special college servants that they took care of this bewildering accumulation with scarcely an accident. He took an extra room in Cambridge to house a great deal of it; and he presented in his lifetime a large contribution to the Fitzwilliam Museum, to which all was to go at his death: but nothing seemed to make any impression on the congested state of his rooms. We may recur to the words of the Master of Trinity about these wonderful collections and their origin:—

"For the last thirty years of his life Glaisher's keenest interest was making his great collection of pottery. It was, I think, soon after 1895 that he turned his attention to this. He had not been elected to the Sadlerian Professorship on Cayley's death, and the term for which he could hold his College Lectureship had nearly expired, he was thus faced with the cessation of work on which he had been engaged for nearly thirty years, and felt the need of another interest. I believe it was on the advice of a great friend of his, Professor McKenny Hughes, himself a keen collector, that he began to collect. The subject he chose was pottery: at first his idea, as he told me later, was to form a collection which would illustrate the development of technique in the manufacture of pottery—to get an early specimen of each new method or process. This, I understand from experts, he succeeded in doing, and his collection is of great value to all students of the craft. But as collections are apt to do it developed far beyond his original intention; he got interested in certain types of pottery—especially slipware—and gradually acquired what I understand is the finest collection of it in the world. He spent large sums in acquiring choice pieces—if you own the best collection then when a very rare piece turns up you have to buy it or it may go to a rival collector and you will be deprived of the lead. He told me once he had never regretted his extravagances but often his economies which had made him let a piece go which afterwards he was always wanting to possess. Collecting was his greatest pleasure; when he came back to Trinity last spring after his serious illness, and when he was still too unwell to go to hall, he would brace himself up to go to the sales in London. Besides pottery he collected old samplers and formed a collection which is one of the best, if not the best, in the world. In a lighter vein, he collected valentines and children's books. These collections are to go to the Fitzwilliam Museum, and will form a delightful and enduring record of this many-sided man."

The Master adds some words about Glaisher's rare humanity:

"to no one did warm friendship mean more." We who enjoyed his friendship during his long presidency of the R.A.S. Club would all subscribe to that statement. The Club could not bear to lose him from the Chair. Even when he became President of the Society itself, in 1901–03, which had in previous instances meant automatic vacation of the Club Chair, it was insisted that he remain our President; and he faced the double responsibility and strain with keen appreciation of the affection so manifested. After he had been twenty-five years President, a special hammer and sounding-board were presented to the Club by one of its members, in honour of the occasion; but Glaisher was still not allowed to resign. After thirty-two years he expressed a decided wish to do so, which, from what we know now, may have had its origin in failing health: but as this valid reason was concealed, the Club insisted on one more year, in honour of which the number of members, formerly thirty-two, was ultimately raised to thirty-three. On the sounding-board, on which the names of successive presidents are inscribed, there was added under Glaisher's name, by special resolution, the words

per xxxiii annos Praeses Gratissimus.

But in spite of his warm affections he never married, so that the name of Glaisher disappears from our lists of Fellows after having had an honoured place therein since 1841, and in the lists of the Royal Society since 1849. From 1871–1903 our lists, and from 1875–1903 the Royal Society lists, contained the names of both father and son. Moreover, for one other year only our lists had the names of James Glaisher (senior) and his brother John, who lived with him at the Cambridge Observatory until he succeeded him in 1836 as the Assistant, when James removed to Greenwich with Airy. In 1845 John Glaisher left Cambridge to become observer to the Rev. J. B. Reade of Stone and Dr. Lee of Hartwell—another link between Dr. Lee and the Glaisher family. In the same year he joined our Society: but he lost his wife only three weeks after marriage, and from that great shock he never recovered. His own death followed within a year. A younger son of James Glaisher, Ernest Henry Glaisher, who followed his elder brother at St. Paul's School and Trinity, and then went out as Curator of the Museum in Georgetown, Demerara, died many years ago.

H. H. T.

Hester Periam Hawkins, widow of Mr. Joshua Hawkins, died at her residence in Reigate on 1928 May 18, aged eighty-one. For many years she had lived with her husband in Bedford, where they inaugurated many remarkable public improvements and developments, particularly in connection with housing. Mrs Hawkins's interests were chiefly religious, political, and social, but she was also very fond of astronomy, and was the author of several small books on the subject, including *The A B C Guide to Astronomy*, which ran through several editions, and *Astronomy for Busy People*. Mrs. Hawkins was a vice-president of the Bedford Women's Liberal Association, and a lifelong supporter

of the temperance movement. A deep piety characterised her thought and writing. She is survived by all her children, three sons and three daughters.

She was elected a Fellow of the Society on 1921 January 14.

Thomas Humphries was born in London in 1841, the eldest son of Dr. E. L. Humphries, who, having previously visited New Zealand as a ship's surgeon, in 1850 brought his wife and family to live there. The voyage was made in the 600-ton barque *Sir Edward Paget*, and took more than a hundred days. The family settled in New Plymouth, where Thomas Humphries went to school. In 1857 he entered the Survey Department as a cadet. In these days there were no horses in New Zealand, and all survey work had to be done on foot. He took part, both as a surveyor and as a combatant, in the Maori Wars of 1860–61, and later received a commission in the Militia. From these days commenced his interest in rifle-shooting, for which he won many prizes ; on one occasion he tied for the championship belt.

By dint of systematic study Humphries quickly made a mark for himself as a surveyor, and rapid promotion followed. He filled a number of posts, until finally, in 1906, he was appointed Surveyor-General of the Dominion. He retired three years later, after fifty-two years' service.

He was particularly interested in the astronomical side of surveying, and wrote a text-book on the subject, which is still used by students. In addition to astronomical work in connection with the survey, such as the determination of the longitude difference between Wellington and New Plymouth, which he carried out in conjunction with the late Dr. Adams, Humphries took part in the observations of the transit of Venus in 1882 and the total solar eclipse of 1885. Up to within a few years of his death he continued to set mathematical problems for the Australasian Survey examinations.

His interests were many and varied, and included sports, music, and church work. His faculties remained keen despite his advancing years, and he died in his eighty-seventh year, at Lower Hutt, Wellington, on 1928 August 30. He is survived by his widow, with whom he had celebrated his diamond wedding, and by a son and a daughter.

He was elected a Fellow of the Society on 1921 March 11.

Walter Claude Johnson was one of those successful business men who, to the great advantage of the Society, have been attracted to its fellowship, though they may not have had time for serious astronomical work. The attraction was partly due to his friendship, through residence on Blackheath, with the Greenwich astronomers and through them with their friends ; and partly to his keen and varied interests in collecting, which led to his acquiring a number of telescopes and other astronomical instruments.

A very beautiful sundial which had been long in his possession was presented by his heirs to the Lewis Evans Collection at Oxford, and very gratefully received. Some of his telescopes also became gifts to

those who could use them more often. His father was a distinguished railway engineer, principal in the firm of Johnson, Martin & Fox. The son was born at Sidmouth on 1848 December 28, and educated at Victoria College, Jersey.

In 1864 he became an articled pupil of Sir Daniel Gooch, and served five years' apprenticeship at the Vulcan Foundry in Lancashire ; after which he attended King's College, London, to study Mechanical Construction and Science.

In 1869 he joined the engineering staff of the Telegraph Construction and Maintenance Company, and was selected to superintend the conversion of the *S.S. Great Eastern* for cable laying. He then accompanied the *Great Eastern* during the laying of the first cable to India, being in charge of the cable-laying machinery ; and afterwards superintended the reconstruction of other ships and took part in the laying of other cables, including the first one to Australia.

On his way back to England from this last enterprise he picked up an abandoned cable between Corsica and Italy, then a comparatively new operation. But as sea travel did not suit him, he determined to start engineering works at Charlton, in partnership with the late Samuel Edmund Phillips.

Among many inventions due to him was a patent protective covering for submarine cables, which was developed and exclusively manufactured by the firm of Johnson & Phillips. Their business rapidly developed in various directions. About 1890, for instance, the Company laid the first electric lighting main across Southwark Bridge into the City of London. The firm was registered as a limited company in 1905. Mr. Johnson remained chairman of the board of directors until 1928 March when he retired.

But he also, with Mr. Bernard Drake as partner, built large works at Bakewell in Derbyshire in 1895, known as the D.P. Battery Company. Moreover, he was largely instrumental in the acquisition and development of the Tudor Accumulator Company, which was purchased from the Liquidator of the Enemy undertakings bearing the same name. All three of these great works were, under his guidance, quickly adapted to meet the requirements of the Government at the outbreak of the war.

He was not only a considerable artist himself, but was keenly interested in artistic matters. He founded the journal known as the *Connoisseur* in 1901, and maintained it throughout the war at great personal cost.

He had various other interests outside his engineering work. He was for two years in partnership with the late Sir William Crookes in attempting to work gold-mining in Wales. The gold recovered, however, amounted to less than £600. He was also associated with the late Lord Crawford in scientific research work. He was a member of the Institutes of Civil Engineers and Electrical Engineers, a Fellow of the Physical Society, and of the Society of Arts.

He married in 1875 Miss Jane Anne Fern, younger daughter of William and Mary Fern, and had a son and two daughters, all of whom

survive him. After a long residence in Eltham and Blackheath, in 1905 he acquired the freehold of Broadstone Place, Ashdown Forest, Sussex, the grounds of which he greatly beautified. He died there in his eightieth year on June 2 after some months of ill-health.

He was a generous founder and supporter of clubs and societies designed for the recreation and betterment of his employees, both at Charlton and in Sussex, and subscribed liberally to the local charities.

He was elected a Fellow of the Society on 1885 December 11.

H. H. T.

The Rev. Edward Bruce Kirk was born in Edinburgh in 1857 and was a son of Professor John Kirk. He studied under Professor Tait at Edinburgh University, where he won the Neil Arnott scholarship for research in Physics. For thirty-three years he was minister of Barrhead E.U. Church, and for a period of twenty-three years he held the David Elder Lectureship in Astronomy at the Royal Technical College, Glasgow. His lectures there comprised the history and development of astronomy from the earliest times to the present day, and attracted large and appreciative audiences. His publications included *Evolution, Life and Religion,* besides numerous astronomical articles. He was a past president of the British Astronomical Association, West of Scotland Branch. He died in Glasgow on 1928 May 22, and is survived by a widow and two sons.

He was elected a Fellow of the Society on 1911 February 10.

Arthur Herbert Leahy, who came from a military family, was born in Corfu in 1857, during the British occupation of the Ionian Islands. He was the eldest son of Colonel Arthur Leahy, R.E., of Flesk, Killarney.

From Uppingham School he went to Trinity College, Dublin, and thence to Pembroke College, Cambridge, where he graduated in 1881 as ninth wrangler, obtaining at the same time a third class in the Classical Tripos. After a year as instructor at the R.M.A. at Woolwich, he became mathematical master at Bradfield (1883–85). Returning to Cambridge, he was elected Fellow (1887) in his old college, appointed a college lecturer, and a year later, bursar, both of which offices he held until 1892, when he was appointed Professor of Mathematics at Firth College, Sheffield. He held this post throughout the transformation and growth of that institution into the University of Sheffield (1905) until his retirement, after thirty years' service, in 1922. He took a very active part in the matters relating to the institution of the University, the framing of its statutes and ordinances, and thereafter continuously in the proceedings of the Senate, and the two Faculties of Science and of Arts. A man of clear insight, with opinions tenaciously held, he was often incapable of recognising defeat in a committee, but he never bore malice, and all his colleagues had a very real respect and affection for him. He was the first Dean of the Faculty of Science (1905–11), Dean of the Faculty of Arts (1919–22), and Public Orator of the University (1912–22). He was president of the Sheffield Literary and

Philosophical Society in 1909, and a vice-president of the British Association in 1910.

He seems to have been first interested in astronomy on his return to Pembroke College. The college possessed an excellent transit circle, which he got put into repair and used for observations. On his removal to Sheffield the College presented the instrument to the University, which mounted it in a small building in the adjoining Weston Park, next door to a large equatorial refractor belonging to the city, whose council entrusted its care to him.

In 1896 he joined a party on the *Norse King* to view the total solar eclipse at the North Cape ; the view being, as is well known, completely spoiled by bad weather. He also went on an expedition to observe the 1905 eclipse.

Whilst a master at Bradfield School he published several mathematical papers in the *Transactions of the Cambridge Philosophical Society*, and a paper by him on Tesseral Harmonics was published in a volume printed to commemorate the incorporation of the University College of Sheffield (1897). But his chief interest began now to be transferred to old Irish literature, with the result that he published several books on this subject. He thus introduced to English readers, in vivid and terse translations, some of the finest pieces of native literature which Ireland produced between the seventh and the twelfth centuries.

After his retirement, he lived at Littlehampton, where he died on 1928 May 16. He was married to Margaret, daughter of William John Chichele Nourse, and leaves one son and one daughter.

He was elected a Fellow of the Society on 1888 November 9.

[The Council is indebted for the above notice to Dr. W. M. Hicks, F.R.S.]

Francis P. Leavenworth was born at Mount Vernon, Indiana, U.S.A., on 1858 September 3. After receiving elementary and preparatory education at the public schools of Mount Vernon he entered the University of Indiana, where he graduated in 1880. He then pursued post-graduate studies at Cincinnati University and at the University of Virginia, and while in residence there he was assistant in the Astronomical Observatory of the University. In 1887 he was appointed director of the Observatory at Haverford College, Pennsylvania. He held this post till 1892 when he became Professor of Astronomy in the University of Minnesota at Minneapolis. On his retirement thirty-five years later he was given the title of Professor Emeritus.

Professor Leavenworth will be remembered as an indefatigable observer of double stars. This work he commenced on a large scale while at Haverford, and he carried it on more or less continuously till his retirement from his professorship in 1927. The results of his measures appeared in a long series of papers in the *Astronomical Journal*, where he also published positions of a number of comets and minor planets from photographs taken with the 10½-inch refractor at Minneapolis. Amongst the observations made with this instrument were

photographs of Eros in 1900 for the determination of the solar parallax. While at Virginia he discovered 250 new nebulæ, and in his later years he turned his attention to long-period variables.

In 1883 Professor Leavenworth married Miss Jennie Campbell of Louisville, Kentucky, and is survived by his three children, a daughter and two sons. He died on 1928 November 12, a year after his retirement from active work. He was a member of the Phi Beta Kappa and Sigma Psi fraternities, and was elected a Fellow of the Society on 1922 June 9.

E. W. Maunder.—By the death of Edward Walter Maunder there passes one who has been a notable figure in the astronomical world of the last half century. His name will always be associated with the study of sunspots and the sunspot cycle, but besides his many contributions to that subject to be found in the *Monthly Notices*, either over his own name or as communications from the Royal Observatory, Greenwich, his activities embraced other branches, and these activities, together with his share in establishing an organization which is universally considered to be an asset of great value to astronomy, it is proposed to describe categorically in the following paragraphs.

In the year 1860 the erection of an instrument at Greenwich, known as the Great or the South-east Equatorial, which carried a telescope with an object-glass by Merz, $12\frac{3}{4}$ inches in diameter, was completed, its avowed purpose being the determination of position. But after an initial effort in that direction which took the form of measuring the system of Saturn, for ten years the instrument was used for desultory purposes, such as making drawings of the planets, examining the surface of the Moon, or observing eclipses and occultations, the most ambitious undertaking being a determination of the heat of some of the brighter stars, made by Mr. E. J. Stone with a thermopile, in the years 1869-70. In his Report of the year 1872 the Astronomer Royal, perhaps inspired by Mr. Christie, who by that time had joined the staff as Chief Assistant, wrote that it might be desirable to procure a good spectroscope for occasional attachment to the telescope, and further, in the same Report, set down his views on adding some observations of a physical nature to the programme of work of the Royal Observatory. He considered that a continued series of observations of solar spots was quite consistent with the character of the establishment, but that it was doubtful whether the same could be said of solar spectroscopy; and that if it was decided that any work of this kind should be taken up, it would be necessary to add another assistant to the establishment. Following up these ideas, a photoheliograph that had been used at Kew was planted in the South ground before the date of the next Report (1873 May), and on 1873 November 6 Mr. E. W. Maunder was appointed Photographic and Spectroscopic Assistant at the Royal Observatory. It may be mentioned as a matter of history that he had competed at an examination held by the Civil Service Commissioners at the end of the year 1872, the first of its kind, to fill vacancies at the Royal Observatories at Greenwich and the

Cape, which resulted in A. M. W. Downing being appointed as Assistant at the first-named and W. H. Finlay as First Assistant at the second. As the result of another similar examination Maunder was appointed as above mentioned, the newly created post ranking as equivalent to that of an Assistant of the Second Class.

The Kew photoheliograph was brought into use in 1874 April and the Greenwich Record of Sunspots begins on April 17, though some photographs were taken before that date with an instrument made by Dallmeyer for the Transit of Venus expedition. One of these was set up in place of the Kew instrument after its return. A spectroscope received from Mr. Browning, adapted for sweeping round the Sun's limb with a view to mapping the prominences, but also available for work on stars and nebulæ, is mentioned in the Astronomer Royal's Report for 1874, and with these instruments Maunder worked in the early years of his career. Wet-plate photography had not then been superseded, and the manipulation of the process was more arduous than the photography of to-day. In the early years a tabulation of the spots only was made, and it was not until the beginning of the year 1877 that a position micrometer for measuring the positions and areas of spots and faculæ on the photographs was procured and used. The spectroscope demanded a great deal of Maunder's attention. There was much to be done in the way of improvement and adjustment of a novel instrument, and at such times as weather and other circumstances permitted it was used by day for sweeping the chromosphere to detect the prominences, and at night for measuring the displacement of lines in the spectra of bright stars to determine, according to Doppler's principle, their velocity in the line of sight, a work in which Mr. Christie took an occasional part. The first of an almost annual series giving the results of these observations will be found in the *Monthly Notices* for 1875 November. It must be said that from the beginning the uncertainty that attended the deduced results was quite realised, and, because of discordances between those with the Greenwich instrument and those obtained by Dr. Huggins, Mr. Christie pointed out in a paper in the *Monthly Notices*, 1876 May, the difficulties and instrumental reasons that militated against complete success; and it implies no derogation of Maunder's efforts and skill to say that these results are not of the same class as others made later with instruments improved by more knowledge and experience. The series was interrupted in the years 1877 to 1879, partly on account of the mounting of a spectroscope of a new type, the half-prism, and partly because of the necessities of the photographic work. In this period, which included a very close opposition of Mars, the instrument was used by Maunder for making sketches of the surface features of that planet, and other occasional observations.

Shortly after Mr. Christie became Astronomer Royal he made considerable reorganisation of the work of the sunspot department. The photoheliograph was modified so that the diameter of the Sun on the photographs was 8 inches instead of 4 as it had been previously; a micrometer was obtained to measure plates of this size; the gelatine

dry-plate process was adopted; steps were taken to procure photographs from various sources to make up deficiencies in the early years, and the scheme was brought into action by which the Greenwich series of photographs was supplemented by others taken in India and Mauritius to make the current record complete. Thus was evolved the complete record of sunspots which was Maunder's staple work for the succeeding thirty years. At first his duty was to make only a journal or a day-by-day record of the spots and faculæ with their areas and positions, but this was added to gradually. Ledgers were formed of individual groups to show the changes in them during their apparition, these were tabulated later as groups that did or did not recur, and, in fact, all was done to extract the essence from this fruitful source of knowledge. Summaries of this kind are to be found in the annual communication to the *Monthly Notices*, entitled "Mean Areas and Heliographic Latitude of Sunspots." But beyond such as these, which may be classed as official routine, there are papers planned and worked out by Maunder that exhibit conclusions of striking interest derived from the sunspot records. "The Determination of the Solar Rotation Period," by himself and Mrs. Maunder (*M.N.*, 1905 June), emphasised the difference of the rotation period in different latitudes, and the proper motion of individual spots; two papers by himself and the present Astronomer Royal that appeared in the years 1912 and 1913 investigated the position of the Sun's axis of rotation; another exhibits the mean daily spotted area of the Sun for a series of years, the northern hemisphere being shown separately from the southern, leading to the conclusion, as he saw it, that the eleven-year cycle holds good for both hemispheres, though there may be differences in detail, and that there are no cycles of multiple or submultiple length. A short series of papers, begun as part of his official work, but continued on his own responsibility, treated of the Distribution of Spot-centres in Heliographic Latitude that culminated in what is generally known familiarly as his "butterfly" diagram, which exhibits this feature very vividly and completely. Deductions he drew from this will be found in *M.N.*, **82**, 537, as part of an address he delivered on this subject in connection with the Centenary Celebration in 1922.

It is not expedient to attempt to give here a complete list of Maunder's communications to the Society, but a series of remarkable papers on magnetic disturbances and their association with sunspots began in 1904 January with a paper "communicated by the Astronomer Royal," discussing only the "great" storms that were recorded between 1875 and 1903, and was followed by another in November of the same year by himself that extended the examination to a much larger number of disturbances, treating them from the point of view of their periodicity. The suggestion that the variations of terrestrial magnetism are connected with the rotation of the Sun had already been made by Hornstein * and Broun,† but a diagram in this

* *Vide* "On the Dependence of the Earth's Magnetism on the Rotation of the Sun," by Professor Hornstein of Prague, Vienna, *Imp. Acad. Sci.*, 1871 June 15.

† Vide *Proc. Roy. Soc.*, 1873 December 18.

paper by Maunder introduced a new point by showing a tendency for magnetic storms to recur after a period of about 27 days, which carried such conviction that it created an interest almost sensational. Conclusions that Maunder drew from his work on this paper that there are certain magnetically active areas on the Sun which may or may not be marked by a spot, and that from these emanate streams which affect the earth, may not be entirely a new thought, but their actuality is here made so convincing that Maunder must always be considered a pioneer in this enthralling research.

The regularity of his work on the sunspots was occasionally interrupted by journeys abroad to take part in the observation of solar eclipses, for since his daily work was photography of the Sun, it is not surprising that his services were in demand on such occasions. The first of these was the total eclipse of 1886 August 29, when he went with a party of well-known astronomers and physicists under the auspices of the British Government to the West Indies, and observing from the island of Carriacou, where Father Perry was his companion, obtained seven photographs of the corona and two of the coronal spectrum. His second official expedition was to observe the eclipse of 1901 May 18, for which he went as observer from the Royal Observatory to Mauritius and obtained a successful series of photographs. For the eclipse of 1905 August he went to Canada at the invitation of the Canadian Government, but on this occasion adverse weather conditions prevented any observations. Besides these eclipses he made journeys to observe others, with expeditions organised by the British Astronomical Association, with which he was closely connected, and of this connection some account may now be given.

Maunder during the early part of his career at the Royal Observatory had made the acquaintance by correspondence and otherwise, perhaps because he was editor of the *Observatory Magazine* as will be recounted later, of many astronomers professional and amateur, among the latter being members of the Liverpool Astronomical Society, an organisation that about the year 1887 comprised as many as six or seven hundred members, resident in all parts of Great Britain, mainly non-professional. Shortly after that date some disaffection arose in the Liverpool Society, which, coming to Maunder's knowledge, gave him the idea that there was room for a similar Society conducted differently in detail. The first definite move was made by Mr. W. H. S. Monck of Dublin, who proposed the formation of a body of this kind in a letter to the *English Mechanic* of 1890 July 18, that was followed by others to the same effect in that journal, and in the number for August 8 one appeared signed by E. W. Maunder saying that a Society upon the lines that Mr. Monck had suggested was then in process of formation, and that the writer would be pleased to receive the names of those who would like to join. It is not necessary to pursue this further. The success that has attended the career of the British Astronomical Association, and the value of the work done by its Sections, a feature that was Maunder's idea, are facts of common knowledge. He nursed and tended it in its early years till it was able to stand alone, and has left

it a thriving, self-supporting body, comprising in its ranks a multitude of keen and skilful astronomers.

The indexes to the publications of the Association show Maunder's versatility. There are many papers to his name, the largest number being, as is to be expected, on sunspots, the solar rotation, and cognate topics. The planet Mars and its supposed canals formed the subject of several communications, his view as to the reality of the latter as Schiaparelli and others had depicted them being that they were the integration by the eye of minute details too small to be separately and distinctly defined, which view he supported by a series of experiments made with the help of the headmaster and a class of boys of the Royal Hospital School, described in a communication to the *Monthly Notices* (1903 June). The zodiacal light was a favourite subject. The study of archaic astronomy, represented by papers dealing with the formation of the constellation figures and their date, had a fascination for him, but beyond this it may be said that he was able to make some useful contribution to whatever might be the subject of the moment. He was Director at various times of the Mars Section, the Coloured Star Section, and the Solar Section of the Association; Editor of its journal almost continuously for ten years and President in the years 1894–96. The eclipse expeditions, organized largely owing to Maunder's inspiration, have been pleasant events connected with the Association. In 1896 a large party made a voyage to Vadsö in Lapland for the purpose of observing the total solar eclipse of August 9 of that year, but the purpose was foiled by adverse weather, though the expedition was a great success from a social point of view. A smaller party, of which he and Mrs. Maunder were members, went to India to observe the total eclipse of 1898 January, and met with complete success, a ray of the corona photographed by Mrs. Maunder on the occasion being traced to a distance of 6 lunar radii from the limb, whilst for observation of the eclipse of 1900 May 28 Maunder went to Algiers with his family with an expedition, which was one of three arranged by the Association on that occasion. Accounts of these expeditions to India and to Portugal, Spain, and Algeria in 1900 have been given in two publications of the Association edited by Maunder.

It will be gathered from this that he had a facile pen and considerable literary skill, and these he exercised throughout almost the whole of his career at the Royal Observatory. The *Observatory Magazine* was founded by Mr. Christie in the early part of the year 1877, and was carried on by him single-handed until his appointment as Astronomer Royal in 1881 August, when he asked Maunder to join him as co-editor, and the number for November bore both names on its cover. From that time until the end of the year 1887 almost the whole duty of producing this publication fell upon Maunder, though for three of the years two of his colleagues were nominally associated with him in the editorship. For a period he supplied *Nature* with a weekly column, and at another the astronomical section of the periodical *Knowledge* was in his charge, and many articles on varied astronomical subjects are to be found in its pages. His book on the Royal Observatory,

Greenwich, which appeared in 1900, is a brightly written and choicely illustrated history of the institution; and another, *Astronomy without a Telescope*, published from the office of *Knowledge* in 1902, in which he collected much of the material that had appeared in his papers on the constellations, the zodiacal light, and on other subjects, has found many readers, and is often quoted from as a classic. Maunder's biblical knowledge was profound, which led to his being asked to prepare the astronomical section of *The International Standard Bible Encyclopædia*, and caused him to produce in 1908 the work, *Astronomy of the Bible: An Elementary Commentary on the Astronomical References of Holy Scripture*, in which he discussed the incidents described in Holy Writ that have astronomical bearing and may be dealt with from points of view of the science. There are two items in the series, called "The People's Books," with his name, and this does not complete the list of his literary efforts. He was an effective speaker and lecturer, and his services on this account were often in demand.

The subject of this note was the youngest of three sons of the Rev. George Maunder, a minister of the Wesleyan Society, and was born in the neighbourhood of London on 1851 April 12. He went to the school attached to University College in Gower Street, and afterwards attended classes at King's College, London. He had some service with a bank in the City of London, but joined the staff of the Royal Observatory as already narrated in 1873. He was twice married. By his first wife, who died in 1888, he had three sons and two daughters, and a son who died in infancy. In 1895 he married Miss A. S. D. Russell, then a member of the staff of the Royal Observatory, a well-known personage in the astronomical world, who has edited for some years past the Journal of the British Astronomical Association. Maunder retired from his post at the end of the year 1913, when he had completed forty years' service, but was recalled with Mrs. Maunder during the war years to carry on the sunspot record. After his retirement, in the years 1914 to 1916 he was Secretary of the Victoria Institute, a Society established in the year 1865 to investigate important questions of Philosophy and Science, especially those bearing upon Holy Scripture, and prepared and read several valuable papers that are published in its *Transactions*. Maunder was a man with no enemies, but many friends. A suavity of manner and a softness in speech were markedly in keeping with a kindness of heart and amiability of character that lay deeper than its outward manifestation. He died on March 21 last, within a month of the completion of his seventy-seventh year, having been afflicted with a painful internal trouble for some years previously.

He was elected a Fellow of the Society on 1875 February 12, was a member of the Council for several years, and served as Secretary from 1892 to 1897.

H. P. H.

George Pearson was born in 1876 January at Kinross, where his father served in the employ of the North British Railway Company. The family soon afterwards removed to Edinburgh, and

Pearson was educated at Roseburn Public School. After completing his elementary education, he was apprenticed as an engraver to Mr.—afterwards Sir—William Peck, then at the beginning of his career as an astronomer. In 1896, when Peck took over the charge of the City Observatory, Pearson was appointed junior assistant. He was of the greatest service to Peck in the preparation of *The Observer's Atlas of the Heavens*. In 1899 he was appointed by Peck to be his private assistant, and in this capacity he constructed the charts accompanying the star-catalogue drawn up by Peck and by the late Mr. T. W. Backhouse of Sunderland. These large maps, 20 inches square, specially arranged for meteor observers, were never published owing to lack of funds.

Mr. Pearson was an expert draughtsman and photographer, and his knowledge of practical astronomy was wide. Two years ago he acted as lecturer on astronomy to the Edinburgh Education Authority. He was also a prominent member of the Edinburgh Astronomical Association. He died suddenly on 1928 August 7. His wife, who survives him, is a sister of the late Sir William Peck.

He was elected a Fellow of the Society on 1925 February 13.

H. M.

Robert Peebles was born on 1864 April 21, and was the son of Robert Peebles of Banbridge, Co. Antrim. He carried on a business as a linen merchant in Wood Street, London, and was an enthusiastic amateur astronomer, all his spare time being spent in observing. He died at his residence, 22 Waldegrave Gardens, Twickenham, on 1928 April 4, leaving a widow, a son, and a daughter.

He was elected a Fellow of the Society on 1923 November 9.

Sydney Royston Pike, who was born at Mauritius on 1903 May 6, was the eldest son of the late Capt. S. R. Pike, R.A. He was educated at Bedford College and later at Balliol, which he entered in 1920, having won the Henry Skynner Scholarship of £100 for astronomy and mathematics. He intended to devote himself to astronomy, which had always attracted him, but decided to equip himself first by the study of mathematics and physics. He graduated B.A. in 1924 with a First Class in the Final Honours School of Physics. Whilst still a student he contributed to the *Monthly Notices* a paper on the development of faint photographic images by fogging. This research, carried out under the direction of G. M. B. Dobson, showed that the optimum fogging density required to bring out the maximum contrast is independent of the exposure time and development time separately, but depends only on the final density of the image. After a year's research in physics at Oxford, Pike was appointed assistant lecturer in physics at the University of Leeds. It was whilst here that he wrote the astrophysical papers on the motions of solar prominences and related topics, which will be long remembered. In 1928 he was awarded a Research Fellowship by the International Education Board, and was granted a year's leave of absence by Leeds University. He proceeded to Mount Wilson in September to carry out researches in solar and stellar physics.

Soon after beginning work he had a severe attack of cerebral meningitis, and though everything possible was done by those on the spot at Mount Wilson, especially by Dr. Hale and by Dr. and Mrs. Dunham, and the ablest specialists were called in, he died on 1928 November 22.

Pike's first astrophysical paper in the *M.N.* (1926 November) dealt with the fact observed by Evershed and St. John that at high levels above a sunspot there is an inflow of gases. Pike pointed out that owing to the deficiency of selective radiation pressure above a sunspot, the gases at high levels must descend under gravity, and therefore the surrounding chromosphere must be sucked in. The velocity to be expected is of the order of that of thermal agitation, and this is observed. This simple and satisfactory explanation has been generally accepted. Pike then proceeded (*M.N.*, 1927 November) to extend the theory of the support of the chromosphere by radiation pressure so as to apply to the motions of prominences. In the neighbourhood of a spot-facula combination, an atom will be expelled away from the facula by excess of radiation pressure and "attracted" to the spot by deficiency of radiation pressure. Pike calculated the resulting trajectories of atoms for various configurations of spot and facula, and showed that these reproduced many of the observed forms of the prominences. His last paper (*M.N.*, 1928 June) called attention to a possible manner of testing the radiation theory of prominences. He showed that there should on this theory be a "sorting" effect for different kinds of atoms; his computations established that above a spot a Sr^+ atom should acquire a smaller limiting velocity than a Ca^+ atom, whilst above a facula the reverse should occur. In a paper published in the *Proceedings of the Leeds Philosophical Society* (1928 April), he turned his attention to a different subject, namely, novæ. He established the important result that the observed increase in brightness of a nova cannot be explained by a rise of temperature only, but must be accompanied by a considerable expansion of the star as a whole. For Nova Aquilæ III. he estimated that the surface must have moved radially with a velocity of at least 200 km./sec. In all his work Pike showed both marked originality and clearness of thought and expression. He had the faculty of seeing into matters which others had passed over as mysteries. It is a great loss to astrophysics that he did not live to continue the lines of research he opened.

Pike had an extremely attractive personality, and endeared himself to his Oxford teachers and his Leeds colleagues, and his presence at meetings of the Society was greatly valued. He was warmly welcomed at Mount Wilson, and made many friends there in a short time. He is buried near the great Observatory where his researches so prematurely ended.

He was elected a Fellow of the Society on 1928 February 10.

E. A. M.

W. E. Plummer.—The death of William Edward Plummer, Director of the Observatory of the Mersey Docks and Harbour Board at Bidston, Liverpool, which occurred on May 22 last, removes from

our ranks the doyen of professional astronomers, for he began observing in the year 1865, and it is doubtful whether any now living, either amateur or professional, can claim to be earlier. Moreover, he was the connecting link between the old astronomy and the new, for he was the first of the old school to be engaged in the kind of astronomy that depends on measurement of the photographic plate, as will appear later in this account of his work.

William Plummer was born in the neighbourhood of Greenwich on 1849 March 26, and at the age of fifteen entered the Royal Observatory as a supernumerary computer attached to the astronomical department, of whom there were then four or five, and soon qualified himself for occasional observing duty with the Transit-circle. In 1868 he transferred his services to Mr. George Bishop, jun., the owner of a famous observatory established by his father in 1836 at South Villa in the Inner Circle, Regent's Park, that had been removed to Twickenham in 1861. The elder Mr. Bishop, a successful business man with a desire to further the interests of astronomy, built this Observatory with the settled idea that it "should do something," and being too old to work personally, took care to enlist the help of those he knew would be good assistants. W. R. Dawes was followed by J. R. Hind in the year 1844, and after the latter was appointed Superintendent of the Nautical Almanac Office in 1853 he continued to exercise a general superintendence over the observatory, the actual observers being the bearers of such well-known names as Pogson, Vogel, Marth, and Talmage. This arrangement remained after Plummer's appointment in 1868, and Plummer always said that whatever skill in observing he possessed was due to Hind's tuition. There appears to have been a recrudescence of activity in this observatory after his appointment. In the *Monthly Notices*, 1870 April, there is a paper "On the Orbit of the Comet of 1683," by W. E. Plummer, prepared at the suggestion of Hind, and the Report of the observatory communicated to the Society in the year 1872, which is in some degree a summary of work of several previous years, speaks of the chart of stars within three degrees north and south of the ecliptic to the eleventh magnitude that is being made from observations; of comets that had been observed during the previous year; and states that Mr. Bishop intended to combine calculation with observation in the proceedings of his observatory. This indicates the range of Plummer's work during these years. He observed comets and computed orbits, and completed the zodiacal charts. A particularly full Report (*Monthly Notices*, 1874 February) shows with what zeal he must have worked at this time. It mentions that the circumstances of the return of two comets have been computed by Mr. Plummer. One of these comets was Brorsen's of 1846, that was detected, at its fifth return, from Plummer's ephemeris in 1873, the predicted time of perihelion passage being only about half a day later than the true one. Plummer was wont at one time to say that he was the only Englishman, besides Halley, who had predicted the return of a comet. The same Report relates how Hind and Plummer watched the stars in the neighbourhood of Tycho's Nova of 1572 to detect

possible changes, because another maximum of that remarkable object was anticipated about that time, though on somewhat uncertain grounds.

This Report was the record of almost the last work done by Mr. Plummer for Mr. Bishop. In the year 1873, on the application of the Savilian Professor of Astronomy, Convocation granted a sum for the establishment of the Oxford University Observatory, and in making arrangements for his staff, Professor Pritchard selected Plummer as his First Assistant. An account of his work and qualifications was sent to Professor Pritchard on 1874 June 4, and appointment followed. The definite date of his removal to Oxford was 1874 September 2, but his duties actually began two months earlier, during which he was helping the Professor in certain preparatory matters.

To state Plummer's work of the next twenty years it may be sufficient to quote the sub-titles of the four volumes of the astronomical observations made at the University Observatory under the direction of Professor Pritchard, for though he, the Professor, was the architect, his assistants were the builders, and, as he was always anxious to acknowledge, it was to their skill that the success of these researches was due. The first volume comprises various subjects, observations of Saturn's satellites, of double stars, of comets, and the elements of the orbits of three double stars. The second is the *Uranometria Nova Oxoniensis*, and contains wedge photometer determinations of the magnitude of all naked-eye stars from N.P.D. 0° to 100°—the record of three years' labour. The third and fourth volumes of the Oxford observations are entitled *Researches in the Stellar Parallax by the Aid of Photography*, which, as the taking of the photographs and the measurement of them were actually done by Plummer and his colleague Jenkins, as in the two earlier volumes, justifies the statement made earlier that Plummer was one of the first workers at modern photographic astronomy. An investigation of the motion of the companion of Sirius (*Monthly Notices*, 1881 December) appears to be independent work by him.

The next undertaking of the University Observatory was the allotted share of the Astrographic Chart and Catalogue, for which Plummer did much experimental work and preparation for Pritchard, but did not actually begin. The Central Committee that had this work in hand met in Paris in 1891, and Plummer attended the meeting in place of Pritchard, who was unable to do so through feebleness due to age, and referring to this incident Professor Turner writes in the biography of his predecessor Professor Pritchard: "The mention of Mr. Plummer's name reminds me that far too little has been said of his indefatigable and excellent work as Assistant. Professor Pritchard's great age precluded his taking any share in the active work of the observatory as a younger Director might possibly have done, and the whole of this work was carried on by the assistants. Further, the Professor was often absent for considerable periods owing to ill-health, and the actual initiative then fell in many instances to Mr. Plummer. That he should go to Paris as the representative of Professor Pritchard was a fitting tribute to the position he had made for himself by great

zeal and skill. The Astronomer Royal wrote to Professor Pritchard expressing his great satisfaction at the arrangement, and the Central Committee paid Mr. Plummer the further compliment of putting him on a sub-committee appointed to examine and report upon the photographic specimens contributed by the various observatories." The degree of M.A. was granted him by the University *honoris causa* in 1889.

In 1892 the Directorship of the Liverpool Observatory fell vacant, and Plummer applied for and was appointed to the office, and remained in it until the end of his life. His prescribed duties were the maintenance of a time-service, the rating and issuing of chronometers, and the keeping of a meteorological record, to which was added later the examination and testing of instruments other than chronometers. But having a transit instrument and an 8-inch equatorial at command his astronomical tastes naturally urged him to make use of them, and in the early years of his directorship the equatorial was used for observation of comets as they came into view, of occultations, and other occasional phenomena. The transit instrument was set in order with a view to determining the latitude and longitude of the observatory, and an investigation of the positions of certain circumpolar stars was carried on for some years, but the result did not prove satisfactory. Seismographs were installed at the observatory under the auspices of the Earthquake Committee of the British Association, of which he was for many years a member, and in this subject he took a keen interest. He was Hon. Reader in Astronomy in Liverpool University for many years and gave lectures with practical demonstration at the Observatory, and his efforts in the cause of local scientific education received recognition by the award to him of the Kingsley medal by the Chester Literary and Philosophical Society.

Mr. Plummer retained his vigour till about three years before the time of his death, which was due to a painful spinal complaint. He leaves a family of two sons and a daughter; the elder son, Professor H. C. Plummer, who was also at one period on the staff of the University Observatory, Oxford, was Andrews Professor and Royal Astronomer of Ireland in the years 1912–21, and is now Professor of Mathematics in the Military College of Science, Woolwich. Mr. Plummer's elder brother John Isaac was observer at Colonel Tomline's Observatory at Ipswich (closed in 1890), and afterwards Assistant at the Hong-Kong Observatory.

W. E. Plummer was elected a Fellow of the Society on 1879 May 9, and served on the Council from 1889 to 1894. H. P. H.

George Augustine Taylor was associated with scientific progress in Australia for over thirty years, and devoted his life to the development of industrial science. He began his career as a cartoonist, and was a contributor to *Punch* (being the first Australian artist to attain this distinction), and for thirty years he was art critic of *The Studio*. He was an enthusiast in colour photography, and in 1924 he came over to England to take coloured photographs of the Exhibition at Wembley. His interests were many and varied, but perhaps the chief work of his

life was in the development of wireless and of aviation in Australia. He was responsible for the installation of the first wireless military station in Australia, and some of his early experiments, commencing twenty years ago, included the firing of guns by wireless, and the controlling and guiding by it of ships at sea, and of aeroplanes. His last wireless experiment was made in 1924, when coloured pictures from a screen block were sent out from Australia House, London. Mr. Taylor was editor of *Building*, *The Radio Journal*, *The Australian Engineer*, and other journals, and was the founder of the Wireless Institute in 1911. He was a prominent builder and town planner, and his efforts to produce improved living conditions in the congested districts of the Australian capital cities were untiring. He died suddenly at his house in Sydney on 1928 January 20, leaving a widow.

He was elected a Fellow of the Society on 1925 January 9.

Henry Martyn Taylor, who at the time of his death was Senior Fellow of Trinity College, Cambridge, was born at Bristol on 1842 June 6, the second son of the Rev. James Taylor, D.D. He was educated first at Wakefield Grammar School, of which his father was headmaster. Thence he obtained a scholarship at Trinity College, Cambridge, where he graduated as third wrangler and second Smith's Prizeman in 1865, the year in which the late Lord Rayleigh was Senior Wrangler and first Smith's Prizeman. He was then appointed vice-principal of the Royal School of Naval Architecture and Marine Engineering at South Kensington, which later became the Royal Naval College at Greenwich. But on his election as a fellow of his college in the following year he returned to Cambridge, and remained there for the rest of his life. He was tutor of Trinity from 1874 to 1884 and mathematical lecturer until 1894. He had been called to the Bar in 1869, and his legal training stood him in good stead when he was called upon to assist in the reframing of the statutes of his college about ten years later.

During his active teaching work at Cambridge, Taylor wrote a number of papers on geometrical subjects, but when on his retirement from his lectureship he was looking forward to more leisure for research work, the great calamity of his life befell him. In rapid succession he lost the sight of each eye, and for the last thirty odd years of his life he was totally blind. So indomitable, however, was his spirit that these last years were in some ways the most active of his long life. For a few years he continued to write mathematical papers by dictation, and was elected a fellow of the Royal Society in 1898. Then he turned his attention to the Braille alphabet. He was struck by the lack of scientific books in this form, and after extending the alphabet to admit of expressing mathematical formulæ by its means, he translated a large number of scientific books into Braille. Some of his friends raised funds for the publication of these books, and thus Taylor's noble and courageous work was made available for his fellow-sufferers. When the burden of years began to tell upon him and forced him to relinquish this task, it was continued under the auspices of the Embossed Scientific

Books Fund which is administered by the Royal Society, and will ever remain a monument to his untiring energy.

Taylor developed interests other than purely scientific ones, and after he had become blind served as a University member of the Cambridge Borough Council and was Mayor in 1900–1901. For some years afterwards he acted as chairman of the finance committee of the Council. His cheerfulness and patience in his terrible affliction will ever remain an inspiration to all who had the privilege of knowing him. He died at his house in Cambridge on 1927 October 16.

He was elected a Fellow of the Society on 1875 May 14.

William John Thorrowgood was born at Portsmouth on 1862 February 8, and spent his life in the service of the Southern Railway; when he retired on 1927 September 30, he had been for seven years superintendent of the Company's signal and telegraph department. His career provides a remarkable example of promotion by merit, for he commenced "in the ranks" as a junior clerk, and rose step by step until he was appointed chief of his department. He was responsible for many important developments in the work of his department, including the installation of the automatic telephone system and of automatic electric clocks at Waterloo and other places, which are synchronised daily at 10 a.m. by the time-signal from Greenwich. Mr. Thorrowgood always took a keen interest in the educational aspect of his work, and besides lecturing at many centres, instituted a signalling school at Wimbledon. He was a member of the Institution of Electrical Engineers, and of the British Astronomical Association, and was a regular attendant at the Society's meetings.

On his retirement from service with the Southern Railway he moved to 23 Denmark Avenue, Wimbledon, where he installed the 8-inch Cooke refractor once used by Dr. Maw, and was looking forward to spending his leisure in the pursuit of astronomy. But he had never really recovered from the death of his wife in 1925, and he died on 1928 October 18, aged sixty-six. He has bequeathed to the Society his 8-inch refractor, together with its house, and £100 towards the expense of moving it.

He was elected a Fellow of the Society on 1922 January 13.

Antonio Abetti, who at the time of his death on 1928 February 20 was the doyen of Italian astronomers, was born of Paduan parentage on 1846 June 19 at San Pietro di Gorizia, then a part of "Italia Irredenta." After taking his degree at the University of Padua in 1867 he at once entered on his astronomical career as assistant to Giovanni Santini, the director of the observatory of that city, and applied himself with so much zeal to the study of meteorology and spectroscopy that on the occasion of the transit of Venus in 1874 he was chosen to take part in the Italian expedition proceeding to Muddapur, in Bengal, to observe the phenomenon. The leader of this expedition was the noted solar physicist, Pietro Tacchini, who in the report on the work done by his party, published at Palermo in 1875, pays a warm tribute to Abetti's

skill in managing to secure an observation of Venus, as seen through the open slit of his spectroscope, projected against the solar chromosphere on the C-line.

This observation, which is figured in Plate 9 of the report in question, was considered remarkable enough at the time, but it was, after all, but an earnest of that extraordinary ability for overcoming technical difficulties which characterised Abetti's whole career as a practical astronomer. His technological talents were still further developed some time later by a year's sojourn for instructional purposes at the observatory of Berlin under Tietjen, so that, when at the comparatively early age of forty-seven he was promoted from his assistantship to Santini's successor, Lorenzoni, at Padua, to become director of the newly constructed Arcetri Observatory at Florence, he found full scope for his marked technical knowledge in the complete reorganisation of that somewhat neglected establishment.

This observatory had gradually developed from a modest institution situated within the city walls and dedicated, about the year 1807, to the service of astronomy. It had been successively presided over by De Vecchi, Pons, and Amici, and although the last named had constantly recommended the transference of the astronomical instruments to a more convenient site on one of the hills surrounding Florence, it was reserved to his successor Donati, the discoverer of the great comet of 1858, to realise the idea of building a suitable observatory to receive them on the classic hill of Arcetri, lying to the south of Florence and sacred to the memory of Galileo.

The building was accordingly opened in 1872 by Donati and, after his death in the following year, came for a brief period under the directorship of Tempel. Owing, however, in large measure to the transfer of Italy's capital to Rome, the establishment had been suffered to pass through a period of neglect, and Abetti, taking over command in 1893, thus found himself free to exercise that genius for instrumental equipment and organisation which, thanks to his energies and those of his son and successor, Dr. Giorgio Abetti, has converted the Arcetri Observatory into one of the most up-to-date astrophysical stations in Europe.

Abetti's first care was to remount the famous Amici objective, constructed about the year 1840, in such a manner that the equatorial mounting itself would be capable of bearing a much heavier optical equipment when an opportunity of increasing the observatory's instrumental means should present itself. This has now occurred, and, under the Reparations Act, a Zeiss objective of 15 inches aperture has taken the place of the old lens, while the whole observatory has been modernised to the extent of including a tower telescope. Details of the latest instrumental equipment of the Arcetri Observatory must be sought elsewhere,* but the fact remains that, thanks to his technical resourcefulness, and more particularly to his skill in adapting the Amici objective of 28·4 cm. aperture to such work as lay well within its powers, as, *e.g.*, the observation of the minor planets and astronomy of position generally,

* See *Jour. Brit. Astron. Assoc.*, **35**, 261, for Professor G. Abetti's description of the new instruments.

Abetti was able to maintain for over twenty-five years an output of observational literature which was as valuable for its accuracy as it was remarkable for its abundance.

The complete list of his publications comprises over eighty separate items, while his astronomical activities, in spite of his retirement under the age limit in 1921, lasted to within a few days of his death.

Ever busy with the technical side of his profession, Abetti conceived the happy idea of founding at Arcetri, and close to the observatory, the new laboratories for Physics and Practical Optics, which several Fellows of the Society had an opportunity of inspecting in 1922 on the occasion of the meeting in Italy of the International Astronomical Union.

But for an innate modesty which governed Abetti's way of life generally, from his scientific pronouncements down to the ordering of his home and his characteristic simplicity of dress, a far wider renown might easily have been his. The interests of his profession, however, were all-sufficient to him, and it was only with difficulty that he could be drawn away from his beloved Arcetri, so that his visits down into the city of Florence, other than those connected with his occupancy of the chair of astronomy at the University, were comparatively rare. The interesting circumstance of the Villa Giojello, where Galileo spent the last years of his life, lying close to the observatory, had always cast a spell over Abetti, and it is significant that he chose this theme for an eloquent oration which he delivered on a festal occasion at the University of Florence in 1901. This was proof enough of his love for his classic surroundings, and he would assuredly have echoed E. B. Browning's lines written from a near-by, but earlier and happier, home of the great Italian :—

> "From Tuscan Bellosguardo,
> Where Galileo stood at nights to take
> The vision of the stars, we have found it hard,
> Gazing upon the Earth and Heavens, to make
> A choice of beauty."

Abetti married in 1879 Giovanna Colbachini, a lady of Padua, who died young in 1891, leaving two sons. The elder son, Dr. Mario Abetti, is the director of the hospital at Empoli, not far from Florence, while the younger son, Professor Giorgio Abetti, has succeeded his father in the directorship of the Arcetri Observatory.

Professor Antonio Abetti had been for many years a member of the Accademia dei Lincei.

He was elected an Associate of the Society in 1921.

W. A. P.

Pierre Puiseux was a son of the celebrated French mathematician Victor Puiseux, who brought him up to a love of science and mountains. At an early age he went from the École Normale Supérieure to the Paris Observatory, where all his scientific work was carried out.

At the outset of his career he was interested in celestial mechanics and particularly in tidal friction and the secular acceleration of the moon. He gave lectures at the Sorbonne on astrophysics and wrote on

stellar astronomy. At the Observatory he was associated with Lœwy in the construction of the equatorial coudé and on the observations made with it. The first work with this instrument was a determination of the constant of aberration. The principal work carried out by Lœwy and Puiseux was on lunar photography. Over 6000 plates of the moon were taken. These were carefully examined by Puiseux, who made the enlargements from which the fine atlas of seventy-one sheets was constructed. It was Puiseux also who wrote the descriptions and discussed the results. This naturally led him to consider the "geology" of the moon. He reached the generally accepted opinion that the lunar formations can be explained as the result of stresses set up at the solidifying surface of an originally liquid sphere, and not through the action of outside forces. He has given in great detail his ideas of the progress of events in the cooling and gradual solidification of the moon. The difference between terrestrial and lunar mountains was attributed by him to a folding of layers on the earth and a rupture of the surface of the moon. In his final work he discussed the oscillation of the moon about its centre of gravity.

Puiseux inherited from his father a love of mountaineering. He was a man of large stature, and in his youth he climbed many peaks in France and outside its borders. He showed great courage in the face of danger when guides, demoralised by fog, were in despair. It is worthy of note that he climbed Mont Blanc alone. During the ascents he studied the geology of the mountains, and the knowledge thus obtained was useful to him in forming his theories of the moon. In the prime of life he was overtaken by a long and cruel illness, so that his alpine ascents had to be given up and even his astronomical work was carried out with a good deal of discomfort and fatigue. For a long time he remained a pathetic figure, but to the end he liked to live in summer within view of the mountains.

Puiseux was a member of the French Academy of Sciences, the meetings of which he regularly attended with the devoted assistance of his wife. He has left a numerous family, who with many other friends mourn his death which took place on 1928 September 28.

He was elected an Associate of the Society on 1917 June 8.

J. J.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Sir Frank Dyson, K.B.E., Astronomer Royal.*)

Transit-Circle.—The number of transits during the year 1928 was 9310, including 158 of the Sun and 103 of the Moon. The observations are reduced to epoch 1925·0 as far as 1928 August. The ledgers of clock and azimuth stars are complete to the end of 1927 and those of zone stars to the end of 1926. In addition to the observations of stars down to magnitude 8·0 and between declinations + 32° and + 64°, commenced in 1922, observations are being carried out on a selected list of 493 stars, north of declination − 15° which will be used as reference stars for the observation of Eros in the opposition of 1930–31. The observation of these stars during 1928 has suffered from cloudy weather.

Comparisons of the observed and tabular longitudes of the Sun and of the planets Jupiter, Saturn, Uranus, and Neptune have been made since the introduction by the *Nautical Almanac* in 1901 of ephemerides based on the tables of Newcomb and Hill. The results of these comparisons up to the end of 1927 are given in the *Monthly Notices* for 1929 January.

Altazimuth.—The Altazimuth has been used for the observation of the Eros reference stars and also for the purpose of checking clock errors. 646 observations of R.A. and 563 observations of declination were obtained during the year, of which 398 and 419 respectively appertained to the Eros stars.

Cookson Floating Zenith Telescope.—During the year 243 plates for variation of latitude have been taken, and 5 plates for determination of scale. They are fairly well distributed throughout the year, but there was a deficiency of plates in June and December owing to cloudy weather. The measurement and reduction are in hand. The final reduction for the period 1919–27 was distributed during the year. The value found for the aberration constant was 20″·447.

28-*inch Refractor.*—During the year 375 observations of 267 double stars were made. Arranged according to separation they are :—

Under 0″·5	63	observations.
0″·5–1″·0	41	,,
1″·0–2″·0	77	,,
Over 2″·0	194	,,

A further list of measures of stars in the catalogue prepared in 1919, and which have been observed on at least three nights up to early in 1928, will be published in the 1927 volume. Previous observations of stars from this catalogue have been published in the Greenwich volumes for 1920 and 1925.

An additional working catalogue of about 2000 stars whose separation does not exceed 3″ is being prepared from Mr. Aitkin's various catalogues of double stars.

On Sunday nights and on other nights in which the instrument is not in use for double star observations it is employed by Dr. Steavenson for the observation of faint variable stars and of planetary detail.

Thompson Equatorial.—During the year 1050 plates have been taken for stellar parallax observations with the 26-inch refractor, and 700 plates have been measured. The parallaxes of 30 stars were published in the *Monthly Notices* for 1928 November. The breech end of the instrument has been modified so as to facilitate the work.

With the 30-inch reflector the work on colour-temperatures of stars has been continued. Utilising the material already obtained, a list of 24 early type stars (B2–A5) has been selected for the purpose of obtaining a set of colour standards. Additional observations of these stars, taken in pairs at equal altitudes, are being made with the object of determining their relative colour temperatures on a common basis. When this scheme of work has been completed these stars will be available as reference stars with which any other star may be compared, the reference stars having been so chosen that it will always be possible and convenient to compare any other star with one of them at an equal altitude. In this way it is proposed to determine the colours of the brighter stars of all types. The colour scale thus obtained will be an *absolute* one, that is to say it will be independent both of the plates and of the optical train employed.

During the year 95 comparisons of pairs of reference stars were obtained, and this part of the work should be completed in the present year. In addition 141 comparisons of 34 other stars of types Bo–Go with one or more of the reference stars have been obtained. The measurement and reduction of the photographs is practically up-to-date. Notes have been published on stars of type Bo–B2 of abnormally low colour temperature in *Monthly Notices* 1928 June and November.

In the spectrograph as originally constructed, a lens was used in the camera. This lens being photographically corrected, it was not possible to focus the red simultaneously with the blue. It was replaced early last year by a concave mirror used in Newtonian form. The spectra are now in sharp focus throughout, admitting of measurement in the extreme red with a consequent extension of the base line.

Astrographic Equatorial.—During the year 86 fields were photographed through the glass for determination of proper motions of stars in the Greenwich Astrographic Zone. The copy for press for Zones 64° to 70° inclusive (comprising vol. i. of the *Astrographic Catalogue*) has been prepared, and Zone 73° has been completely rephotographed.

In addition to the above, 5 plates of the Pleiades have been taken at the request of Professor Hertzsprung, and a number of plates have been taken of the fields which will be utilised for the purpose of observing the gravitational deflection of light at the Solar Eclipse of 1929 May 9.

The largest proper motion found during the year was that of Astrographic Catalogue 73°·857, photographic magnitude 10·7, for which the proper motions in right ascension and declination were found to be respectively + 55″ and − 16″ per century.

Miscellaneous Equatorial Observations.—Six disappearances and one reappearance of stars occulted by the Moon were observed.

Photoheliograph.—Photographs of the Sun were obtained on 267 days at Greenwich and on 340 days at the Cape. On 4 days photographs were not taken at either Observatory, but on 3 of these days negatives are available at Kodaikanal.

For 1928 the mean daily spotted area, corrected for foreshortening, was approximately 1250 millionths of the Sun's hemisphere. The published values for the preceding four years, 1924–27, are 276, 830, 1262, and 1058 respectively. A comparison, based on Greenwich data 1874–1927, has been made between magnetic storms and Sunspots. The results obtained so far have been published in *Monthly Notices*, **88**, 556, and **89**, 84.

Clock and Time-Service.—The free pendulum clock, Shortt No. 3, has been used throughout the year as Standard Sidereal Clock, Shortt No. 11 being kept as reserve and compared regularly with No. 3. A discussion of the performance of the two clocks is given in *Monthly Notices*, **88**, No. 5, and an extension of the discussion in *Monthly Notices*, **89**, No. 3.

The mean time free-pendulum clock, Shortt No. 16, now controls all clocks used for mean time-signal distribution. This arrangement gives facility for the greater regularity of individual signals throughout the day. When necessary, the mean time installation is set to time by the usual electromagnetic method.

The transmission through the Rugby wireless station of a rhythmic series of time-signals at 10^h and 18^h, commenced on 1927 December 19, has been maintained throughout the year, and hourly signals have been transmitted as usual to the G.P.O. Since November 1 the control apparatus arranged to transmit six clock beats at every half-hour to the British Broadcasting Corporation has been modified to send the six beats at 15-minute intervals. Following a suggestion made, the British Broadcasting Corporation courteously agreed to transmit from the Experimental Station at Chelmsford twice daily at 13^h and 21^h (1 hour earlier during summer time) the six clock beats on the wavelength in use at that station, usually 24 metres.

Wireless time-signals from Rugby, Paris, Nauen, Annapolis, Bordeaux, and some B.B.C. transmissions are regularly received and automatically recorded.

By arrangement with the Hydrographer of the Navy, the errors of the Rugby time-signals derived from reception at Greenwich have

been published and circulated periodically in *Notices to Mariners* throughout the year. Since July 1 the errors of the signals received from Nauen, Annapolis, and Bordeaux have also been included in the same periodical publication.

Observations with Transit B.—Observations of clock error were made upon 64 nights.

Eclipse of the Sun.—During the latter part of the year much attention has been given to preparations for the Eclipse of 1929 May 9. Dr. Jackson will be observing at Alor Star in the Malay States, and Mr. Melotte at Pattani in Siam on the other side of the peninsula about 100 miles away. Their main problem is a redetermination of the gravitational deflection of light. Dr. Jackson will use a 7-inch lens of 21-feet focus fed by a pyrex cœlostat kindly lent by Mr. Evershed, and Mr. Melotte will use the Astrographic telescope mounted equatorially. Observations include large scale photographs with a 6-inch object-glass of 45-feet focus by Alvan Clark, kindly lent by Mr. Worthington and used in 1927 at Giggleswick, and small scale photographs of the corona in infra-red light.

Printing.—The volume of Greenwich observations for 1926 and its separate parts have been distributed, together with the volume of Declinations of Stars from Observations of Transits across the Prime Vertical made with the Altazimuth in the years 1923–26, referred to in the previous report. A volume of observations made with the Cookson Floating Zenith Telescope in the years 1919–27, for determination of Variation of Latitude and the Constant of Aberration, has also been distributed.

The printing of the Greenwich observations for the year 1927 is well advanced.

Miscellaneous.—Mr. A. H. Miller of the Dominion Observatory, Ottawa, visited the Observatory during the Summer and carried out a series of pendulum experiments for the determination of gravity. These experiments formed part of a series of comparisons of the value of gravity at American and European stations. Mr. Miller's observations at Greenwich and Potsdam gave a difference in good agreement with previous determinations.

Dr. Öhman of the Observatory of Upsala, Mr. S. Plakidis of the Observatory of Athens, and Dr. Petersen of the Observatory of Upsala, each visited the Observatory for a period during the year.

Royal Observatory, Edinburgh.

(*Director, Prof. R. A. Sampson, F.R.S., Astronomer Royal for Scotland.*)

The activities of the observatory have been, generally speaking, the same as last year.

With the transit-circle, time has been determined on every occasion that permitted, and some material has been accumulated to elucidate the cause of erratic determinations. With the microchronograph the four principal clocks, Riefler No. 258, Leroy No. 1230, Shortt No. 0,

and Shortt No. 4, have been compared with one another daily. A new pen chronograph by H. Wetzer has been introduced, to replace that by Fuess hitherto used, and has proved a very satisfactory instrument.

Reception and recording of wireless time-signals from Bordeaux (8^h), Rugby (10^h), Nauen (12^h), and Annapolis (17^h) have been very satisfactory throughout the year; the introduction of a filter-panel has effected a great improvement.

The solar spectroscope has continued in use for obtaining plates for the determination of the equatorial value of the solar rotation. With the Cooke 6-inch photo-visual and objective prism, the spectra of stars down to the third magnitude are under re-observation. Some photograms of the spectra have been made with the Koch photometer. The material accumulated is under discussion.

The Koch photometer has been dismounted and partly reconstructed in the workshop, to admit the use of photo-electric cells of commercial types, and to effect some other improvements. Laboratory work on the photographic plate has been continued, and a further paper was published by Dr. E. A. Baker in the *Proc. R.S.E.*

Measures of the magnitudes of stars on the Perth (W.A.) astrographic plates, upon the Perth scale, have been continued. No progress has been made towards printing the measures made. A part of zone $-40°$ was printed at the charge of the West Australian Government, but this has ceased.

Seismological and meteorological observations have been continued as heretofore.

The construction of the new 36-inch Cassegrain reflector and its spectrograph has proceeded actively. The reflector is in large measure completed, and it is hoped that its mechanical parts may be on exhibition at the North-East Coast Industrial Exhibition at Newcastle-on-Tyne in the coming summer. Preparations for receiving it at the Royal Observatory are well forward, including the construction of a new floor in the East Dome, and a new photographic and silvering room immediately below.

The 15-inch refractor is in the hands of Messrs. Grubb, Parsons & Co., for reconstruction of the stand and driving clock and for general overhaul.

Royal Observatory, Cape of Good Hope.
(Director, Dr. H. Spencer Jones, H.M. Astronomer.)

Reversible Transit-Circle.—Observations have been continued of the programme commenced in 1925, which includes an extended list of zodiacal stars, together with all stars south of $-30°$ Dec. and brighter than $7^m{\cdot}5$. 832 observations of stars in the second list of reference stars for the Eros opposition of 1930–31 were also obtained. It is desired to secure two observations of each of these stars in each position of the instrument: of the 402 stars in the list, 190 remain to be observed, of which 125 have already been observed two or three times.

It is hoped that the observations of these stars will be completed during the early part of the present year.

The number of meridian transits observed during the year was 13,383. The Sun was observed on 187 days, Venus on 142 days, and Mercury on 81 days. In accordance with the resolution adopted by the Commission on Meridian Astronomy at the meeting of the International Astronomical Union in Leiden in July last, observations of Vesta were secured on 28 nights.

Current reductions are well advanced, and ledgers for the *Second Cape Catalogue* for 1925, based on the present programme of observations, have been commenced.

Zone Observations.—Preparations are in hand for the inauguration of a programme of photographic zone observations according to methods developed by Professor Schlesinger. A wide-angle triplet lens of 6 inches aperture, covering a field of 25 square degrees, is under construction by Messrs. Taylor, Taylor & Hobson, and a long-screw measuring machine for the measurement of the 18-cm. square plates is being made by Messrs. Adam Hilger Ltd.

It is proposed to photograph with this lens the area of the sky from Dec. − 30° to the South Pole, in zones of 5 degrees in declination. The zone of Dec. − 30° to − 35° will be observed first. The selection of reference stars for this zone is now in progress.

Positions of these stars will be derived from differential observations made with the old (non-reversible) transit-circle.

Heliometer.—Observations of the major planets near opposition have been continued, and the following observations secured :—

Opposition of Neptune	.	72	obs.	in	distance	on	7 nights.
,, ,, Saturn	.	82	,,	,,	,,	,, 11	,,
,, ,, Uranus	.	76	,,	,,	,,	,, 8	,,
,, ,, Jupiter	.	60	,,	,,	,,	,, 8	,,
,, ,, ,,	.	48	,,	,,	position angle	,, 7	,,
,, ,, Mars	.	82	,,	,,	distance	,, 5	,,
,, ,, ,,	.	8	,,	,,	position angle	,, 1	,,

The reductions of the observations for the years 1922 to 1927 have been completed. Those for the year 1928 are in hand.

Victoria Telescope.—The telescope was in use on 263 nights during the year for stellar parallax determinations. 2231 plates were secured, of which 89 have been rejected for various reasons as unsuitable for measurement. The number of plates measured during the year was 1959. It is hoped to publish shortly a first list of parallaxes.

5 plates were secured for the determination of the scale of the instrument. At the request of Dr. Schlesinger, in connection with some investigations on the distribution of light in globular clusters, out-of-focus plates of the clusters Messier 5 and 47 Tucanæ, and 6 focus plates with exposures on Præsepe and ω Centauri were secured.

Astrographic Telescope.—The following plates were taken with this instrument :—

	No. of Plates.	No. of Exposures.
Cape Astrographic Zones (for proper motion)	235	938
South Polar region	14	54
Comet Skjellerup, 1927 *k*	9	10
Comet Forbes, 1928 *c*	6	9
Nova Pictoris	14	22
Vesta	3	3

The programme of reobservation of the Cape Astrographic Zones for the determination of proper motions has now been completed. The measurement and reduction of these plates is in progress. 483 plates were measured, either direct or reverse, during the year. At the present rate of measurement, several years will be required to complete the measurement and reduction.

Nova Pictoris.—Photographs of Nova Pictoris through filters and at different focal settings were secured with the Astrographic Telescope (14) and with the Victoria Telescope (15). These photographs have shown that the rings, observed photographically, are an optical phenomenon, depending on the colour curve of the objective and the peculiar distribution of light in the spectrum.

In May, the Tessar Lens Camera (aperture $8\frac{1}{2}$ cms., focal length 30 cms.) was mounted, together with an objective prism, on the 6-inch telescope, and 18 plates, including plates for adjustment, were secured. In July, the 8° objective-prism was mounted on the Victoria Telescope, with which 2 test plates and 2 spectra of the nova were secured. The development of the Wolf-Rayet spectrum is shown, but though the nebula lines N_1 and N_2 are absent, λ 4363 is still strong. The continuous spectrum is very feeble.

Photoheliograph.—700 photographs of the Sun to supplement the Greenwich series were secured on 340 days during the year. Visual observations for zero were made weekly. Original negatives to November 29 and duplicates to November 15 have been forwarded to Greenwich.

Occultations.—9 observations of disappearance at the dark limb, 7 of disappearance at the bright limb, 11 of reappearance at the dark limb, and 2 of reappearance at the bright limb were observed, as well as an occultation of Jupiter.

Night-Sky Observations.—Observations of the brightness of the night-sky were continued and observations were secured on 151 nights. This work forms part of the co-operative scheme arranged by Lord Rayleigh.

Time-Service and Wireless Time-Signals.—The apparatus for the automatic emission of the international (Onogo) type of time-signals, ordered from the firm of Belin of Paris, was received in February. Considerable trouble was experienced with the apparatus in the initial trials, necessitating alterations which were carried out in the Observatory workshop. The emission of the Onogo signals, *via* the Slangkop wireless station, replacing the signals hitherto emitted, was commenced

on September 15. The purchase of a Shortt Synchronome free-pendulum mean time clock for the control and synchronisation of the emitting apparatus has been approved by the Union Government; the clock is now under construction.

The following observations of the scientific rhythmic signals sent out from Bordeaux and Rugby were obtained during the year :—

		No. of Days.
Bordeaux	8^h	275
,,	20^h	148
Rugby	10^h	288
,,	18^h	138

An 8-valve Marconi Receiver (Type R.g. 12), in conjunction with a directional frame aerial, is used for the reception of the signals, which are observed aurally. A Marconi recorder is on order, the use of which it is hoped will reduce the accidental error of the reception and eliminate the small personal systematic errors to which the present methods of reception are liable.

A discussion of the observations secured during the international programme of longitude determinations, 1926 October-November, yields the value

$$1^h\ 13^m\ 54^s{\cdot}597\ \mathrm{E} \pm 0^s{\cdot}007$$

for the longitude of the irreversible circle. Fuller details will be published in due course.

Publications.—The following publications have been issued :—

1. *Photographic Magnitudes of the Cape Zone Catalogue*, containing photographic magnitudes of the 20,843 stars in the *Cape Zone Catalogue* for 1900, together with an account of the method of deriving the magnitudes and a discussion of the results.

2. *First Cape Catalogue of Stars for Equinox* 1925, containing the positions of 4408 Boss Stars which culminate within 70° of the Cape zenith, together with 161 additional miscellaneous stars.

Comparisons with the catalogues of Boss and Eichelberger, and with the *Second Cape Fundamental Catalogue* for 1900, are given in appendices.

3. *Radial Velocity Determinations* (*Cape Annals*, vol. x., part 8) including spectroscopic determinations of the constant of aberration, the orbits of 13 spectroscopic binary stars and individual results of radial velocity determinations not hitherto published in the *Cape Annals*.

Cape Independent Day Numbers for 1930 has been computed, printed, and issued.

Personal.—Mr. Woodgate retired on August 12 after thirty-eight years' service in the Observatory. Mr. Jackson was promoted to the rank of Assistant and Mr. Mullis to that of Junior Assistant (Higher Grade). There is at present one vacancy in the ranks of Junior Assistants.

H.M. Astronomer attended the meetings of the International Astronomical Union in Leiden and of the Astronomische Gesellschaft in Heidelberg.

Armagh Observatory.
(*Director, Rev. Wm. F. A. Ellison.*)

A further series of 65 remeasures of double stars from the *Potsdam Catalogue* was made during 1928, and published in *Monthly Notices* for November.

Drawings of Mars and Jupiter were made as opportunity served, but the number of nights suitable was much restricted by the unusually cloudy weather prevailing during the apparitions of these planets.

A small number of transits of clock stars were taken, but the old-fashioned and obsolete shutters of the Transit Room handicap this kind of work severely. The rating of clocks has to be done largely by the radio time-signals until this state of things can be remedied. Extensive repairs to the Transit Room and adjoining parts of the buildings also held up work in this direction for some months. The small grant of £100 now made annually to the Observatory by the Ulster Government has alone made this possible, and saved the east wing from actual dilapidation.

The 6-inch equatorial has been used chiefly for solar work and for demonstrations to visitors, who are fairly numerous at times. The 10-inch has been employed upon the above micrometrical work, and this and the 18-inch mirror for planetary work. The 18-inch mirror was removed from its cell during the summer for resilvering, and the occasion was utilised to refigure it slightly. Its correction, which had always been a little under the mark, was raised to the full paraboloid. After remounting, it was at once seen that a very great improvement in its performance had resulted from the operation. Star images are like pin-points, and planets of an outstanding sharpness which emphasises all the finest details, whenever the air is at all passably steady. The Observatory now possesses, in its three equatorials, instruments of the very highest optical excellence.

The climatological work takes up much of the Director's time, and to some extent crowds out astronomy. The bulk of this was formerly done by an assistant; but regrettably reduced income has made it necessary to dispense with this luxury.

Cambridge Observatory.
(*Director, Professor A. S. Eddington, F.R.S.*)

Since the last report, vol. 24, pt. 2, and vol. 26 of the *Cambridge Observations* have been printed and distributed. These contain respectively the Catalogue of Zodiacal Stars (meridian circle) and the Catalogue of Photographic Proper Motions.

Work with the photo-electric cell has occupied the greater part of the observing time. One cell out of six tried was found to be workable, and up to the end of the year was giving fairly consistent and uniform results. Without pressing the applied voltage to the working limit,

it was sensitive enough for stars as faint as $5^{m}\cdot5$. On five nights in December two early type stars of low colour-temperature (ζ Persei and 9 Cephei) were observed in comparison with stars of normal colour; the effect was seen to be strongly marked, and a preliminary reduction gave colours corresponding to types A3 and F0 respectively.

Seventeen plates were taken for proper-motion determinations, and eight new regions were measured. Four papers relating to the discussion of proper motions have been communicated to the *Monthly Notices*, including one by Dr. Smart giving a method of determining the constants of the two streams from proper motions larger than a fixed magnitude.

Professor J. J. Nassau and Mr. R. O. Redman were working at the observatory up to the summer on the relation between absolute magnitude and spectral type. The combined result of their work is to give three determinations by independent methods and data of the position of the central line of the Main Series and the average dispersion of the stars with respect to it. Mr. Redman left to take up a Fellowship at the Dominion Observatory, British Columbia. In the current academical year the Observatory welcomes Dr. Otto Struve from the Yerkes Observatory, who is spending the year in Cambridge. Dr. S. Plakidis from the Athens Observatory has come since the end of the year. Mr. J. C. P. Miller is engaged in research on the theory of Cepheid pulsations; and Mr. J. B. Langford is working with Dr. Smart on proper motions. Four other research students are working under the supervision of the Director.

The 8-inch telescope bequeathed to the Society by the late Mr. W. J. Thorrowgood has been lent to the observatory, and at the end of the year was in course of removal to Cambridge. The need of an instrument of this intermediate size for the use of research students has long been felt, and in many other ways its acquisition will be of great service.

Solar Physics Observatory, Cambridge University.
(*Director, Professor H. F. Newall, F.R.S.*)

Spectroheliograph.—Photographs of the Sun's disc in K_{232} light were obtained on 112 days (previous year, 108); and photographs of the prominences at the Sun's limb were obtained on 101 days (previous year, 92).

After the diminution of solar activity about the beginning of the year there was a marked increase during the third quarter, resulting in large disc disturbances and prominences.

The examination of flocculi for motions involved during their growth has been considered.

For the year 1927 October 1 to 1928 September 30, the Director of the Kodaikanal Observatory has sent 338 spectroheliograms showing the Sun's disc in K_{232} light.

Bromide prints of 455 photoheliograms from negatives taken at Greenwich, the Cape, and Kodaikanal Observatories have been received

from the Astronomer Royal, for the periods 1925 July to September and 1927 January to December.

Application of Interferometer Methods to the Spectroheliograph.—Extensive trials of Professor Newall's method of combining a Fabry Perot étalon with the spectroheliograph have been made with a view to measuring velocities in the solar atmosphere. A suitable mount for the étalon was designed and made after some experiments, and photographs taken in the light of Calcium (K line) and of Hydrogen Hα gave promising results. A paper is to be communicated to the Society.

Facilities were given to Mr. W. Ewart Williams of King's College, London, who had quite independently arrived at the same method and who had asked for opportunities for trials with the spectroheliograph at Cambridge.

Study of Sun-spot Records and Prominences.—The investigation of the evidence for the existence of related sequences of outbursts of sunspots has been continued.

The records of prominences obtained at Kodaikanal Observatory during the year 1927 and received in MS. through the kindness of Dr. Royds have been plotted in continuation of the previous observations, and the results for a 22-year cycle are being prepared for publication.

Total Solar Eclipse 1929 *May* 9.—Preparations for observations in the Malay States have involved a considerable expenditure of time. The item of chief interest is the design and preparation of a spectroscope for the photometry of the "flash" by the method of a moving plate. Provision has been made for the simultaneous taking of two spectra of intensity-ratio about 10 : 1 by the use of a plane parallel reflecting plate. A very small image of the Sun is to be thrown on the slit of the spectroscope (which is to be placed radially) to secure effectively a point image of the chromosphere and hence an integrated spectrum which can be resolved by measurement into a variation with height without the ambiguity present in a method using a tangential slit.

Studies of stellar spectrographic work with the Newall refractor have been continued, in particular in securing spectrograms of α Andromedæ, β Persei, and β Lyræ.

Further measurement and study of the spectrum of α Andromedæ have been carried on, but further spectrograms are still desired.

Attention was called by A. H. Joy in 1926 (*Ap. J.*, **63**, 281) to a series of radiation bands or lines which occurred only in the spectrum of *o* Ceti at or near the maximum of 1924. These bands have been identified with bands of Al_2O_3, and a paper by Mr. Baxandall giving the evidence and the results was communicated to the Society (*M.N.*, **88**, 679). Evidence has also been found for the existence of absorption bands of Al_2O_3 in the normal spectrum of *o* Ceti.

Through the kindness of Mr. Wright of the Lick Observatory a number of excellent stellar spectra (enlarged positives on glass) representing the subdivisions of the M group have been received. They have been measured, and evidences of striking changes amongst the lines have been found in successive spectra from *Ma* (α Orionis) to *Md* (*o* Ceti). It has been found that α Orionis unexpectedly contains

lines of ionised iron and titanium which are so prominent a feature in A and F types.

A paper by Dr. Carroll on the effects of the expansion and rotation of a star on the contour of its spectrum lines has been communicated to the Society (*M.N.*, **88**, 548).

Attention has been given to photometric problems and to the design of a recording microphotometer suitable for astrophysical purposes.

Meteorological Physics.—The study of the electrical fields below cumulo-nimbus clouds has been continued. The introduction of a semi-automatic type of apparatus has made it possible to obtain fairly complete records of the electrical fields below thunderclouds and of the effects on the field of very close lightning discharges. Successful records have been obtained on several occasions, and the sign and magnitude of these effects have been determined.

Dunsink Observatory.
(*Acting Director, Mr. Charles Martin.*)

The time-service to Dublin has been continued as in previous years. The meridian circle has been used only for time determination, a comparison being made daily between Greenwich and Dunsink mean time.

The Observatory has been used mainly for teaching purposes, students being welcome in the day for instrumental instruction, and any clear evening for observational work.

Durham University Observatory.
(*Director, Mr. Harold Thomson, M.Sc.*)

The work on long-period variable stars has been continued. The weather conditions during the first eight months of the year were again very bad, but it was possible to obtain about 650 determinations of magnitude during the year.

Preparations are being made for the temporary installation of a seismograph to ascertain the suitability of the site for this instrument.

The usual meteorological observations have been carried out and the results forwarded to the Meteorological Office.

Imperial College, South Kensington.
(*Assistant-Professor H. Dingle.*)

The observatory has been open as usual for the instruction of students, and spectroscopic research has been carried on throughout the year in the laboratory. The laboratory equipment has been increased by the purchase of an excellent silvered dense glass prism from

the Joint Permanent Eclipse Committee. This has been mounted in the large Littrow spectrograph with a lens of 12-ft. focus. The following papers have been published during the year :—

Professor A. Fowler : " The Spectrum of Doubly-Ionised Oxygen (*O*III) " (*Proc. Roy. Soc.*, **117**, 317).

Professor A. Fowler and Mr. E. W. H. Selwyn : " The Arc Spectrum of Carbon " (*Proc. Roy. Soc.*, **118**, 34) ; " Further Investigations of the Spectrum of Singly-Ionised Carbon (*C*II) " (*Proc. Roy. Soc.*, **120**, 312).

Assistant-Professor H. Dingle : " The Spectrum of Fluorine (*F*I)," Part II. (*Proc. Roy. Soc.*, **117**, 407) ; " The Spectrum of Doubly-Ionised Fluorine (*F*III) " (*Proc. Roy. Soc.*, **122**, 144).

Mr. L. J. Freeman : " The Spectrum of Doubly-Ionised Nitrogen (*N*III) " (*Proc. Roy. Soc.*, **121**, 318).

Mr. W. E. Pretty : " The Swan Band Spectrum of Carbon " (*Proc. Phys. Soc. Lond.*, **40**, 71).

In addition, Messrs. Symons and Conneily have completed their studies of the Zeeman effect for the spectrum of gold and the secondary spectrum of hydrogen respectively, and a paper by Mr. Pearse on the structure of the band spectrum of magnesium hydride has been accepted for publication by the Royal Society. Other investigations also are in progress.

University of London, University College Observatory.
(Director, Professor L. N. G. Filon, F.R.S.)

The routine work of the Observatory has been carried on as in former years. The 10-foot Rowland Grating was used during the early part of the summer for comparing the absorption spectra of sub-halide bands, produced in an electrical furnace at 1100° C., with the sun's spectrum. The work was interrupted at the end of June when the grating had to be dismantled owing to structural alterations in the College.

Towards the end of July the building of a new Observatory in Mill Hill Park to house the 24-inch reflecting telescope by Grubb, presented to the University by Mr. J. G. Wilson, and the Rowland Grating from University College, was started. The Observatory is being built for the University of London, and University College has undertaken its administration for a term of five years in the first instance. The Hendon Urban District Council have very kindly provided the site, which is easily accessible for students, while sufficiently far from London to ensure a reasonably clear atmosphere. The 24-inch reflector has been temporarily assembled in the workshop at University College for the purpose of general overhauling and making such alterations as were thought desirable. The object glass of the original guide telescope was missing and a new guide telescope has been installed, fitted with the 6-inch object glass by Cooke, which was purchased for the Observatory

prior to the Eclipse Expedition of 1927 June. The Director and Mr. C. C. L. Gregory have been appointed "Director" and "Wilson Observer" respectively to the new Observatory.

Mr. E. G. Williams, a former student, was appointed as Research Assistant at the Norman Lockyer Observatory, and commenced work there in May.

Radcliffe Observatory, Oxford.
(Director, Dr. H. Knox-Shaw, Radcliffe Observer.)

The programme of work with the 24-inch refractor on the proper motions of stars in the Kapteyn Selected Areas has been continued. Though distinctly better than in the previous year the observing conditions were disappointing, the fine weather occurring in the summer months when the nights are short and when observations are least wanted. For despite the difference in length of the summer and winter nights, the photography of the areas in the second twelve hours of right ascension is nearing completion, whereas very slow progress is being made with the other half of the programme. During the year 37 plates were exposed on the Selected Areas, of which 20 have been passed for measurement. Twelve other plates were taken, 5 of them for testing the magnitude equation, and 6 being experimental plates through colour screens in connection with the determination of the colour indices of the stars in some of the Cambridge proper motion regions.

Thirty plates have been measured and the reduction of sixteen areas has been completed during the year. Of the 135 areas in the programme, 51 have now been completely reduced, and the photography of 63 areas has been finished. Four pairs of plates taken east and west of the pier to test for magnitude equation have been reduced. They furnish values of the magnitude displacement in excellent agreement with those given by the proper motion plates, and thus indicate that the error is due almost entirely, if not wholly, to the present state of the objective. The third and fourth lists of stars found to have annual proper motions exceeding 0″·1 have been published in *M.N.*, **88**, 181, and **89**, 267.

The hope expressed in last year's report that a different form of lubrication might cure the troublesome vibration, which had affected the telescope for a couple of years, has been justified. A mixture of castor oil and graphite forced into the upper bearings of the polar axis by means of a motor-car grease gun has entirely removed the trouble.

The work on Hornsby's meridian observations, in which Dr. Jackson is collaborating, has progressed steadily. Apart from the possibility of a new solution throughout for clock error, the necessity for which is under consideration, the reduction of the right ascensions of ninety-one standard stars and of the Sun has been completed for the two periods 1774 to 1784 and 1790 to 1798; those of the Moon and planets have been done for the first period only. From various considerations it

seems that these two periods comprise the best of the observations, and it has been decided to omit the other years, at any rate for the present. Work is now proceeding on the declinations, those of the Sun for both periods being well advanced.

The R.A. observations of the Sun indicate a correction to Newcomb's tables which increases steadily from 1774 to 1790 by an amount which exceeds $0^s.2$, and then declines to 1798. Those of the stars confirm the Boss system of proper motions rather than those of Eichelberger as regards variation both with right ascension and with declination.

University Observatory, Oxford.
(*Director, Professor H. H. Turner, F.R.S.*)

The extension of the library (four rooms in all above ground, with a basement for the seismographs, provided by the generosity of Dr. J. E. Crombie of Aberdeen) was completed during the year, and represents a great increase in comfort of working. The seismographs were transferred in the autumn from the basement of the Clarendon physical laboratory, where they had been since 1908, to the new Crombie basement. They had been mounted on the piers erected by Professor Clifton forty years ago for the use of Professor C. V. Boys in his well-known Cavendish experiment (1891–93). The return of the basement to the use of the laboratory was made the occasion for recording these two generous loans on a small wall-plate. Professor Boys came to Oxford and recalled, to the delight of a large audience in the Clarendon laboratory, the circumstances of the invention of the quartz fibre and his use of it for weighing the Earth. The new pier (8 ft. by 4 ft.) has not yet settled down, so that the seismograph zeros have wandered in a troublesome manner; but during the Director's absence in the United States at the end of the year, Miss Bellamy found that the floor of the basement (from which the pier had been carefully isolated) was quite stable, and both seismographs are now working satisfactorily. One of the new upper rooms has been assigned as the John Milne Library to contain the seismological books collected by him, with suitable additions.

The Director visited New York, as above noted, to attend the meeting of the American Association for the Advancement of Science (December 27-January 2) as a special representative of the British Association. The Director and Dr. Fotheringham attended the meeting of the International Astronomical Union at Leiden, July 5–11.

The tenth and last volume of the Vatican section of the *Astrographic Catalogue* was completed and distributed during the year. A letter of thanks for the help of the University Observatory in this work was received from Cardinal Maffi, Archbishop of Pisa and President of the Vatican Observatory, and was printed in the *Oxford University Gazette* with the Vice-Chancellor's approval. Cardinal Maffi further sought an audience of His Holiness the Pope, in consequence of which three medals were received (through the Foreign Office), all of the same design,

a gold medal for the Director, and two silver ones for his assistants, Mr. F. A. Bellamy and Miss E. F. Bellamy.

Dr. Fotheringham (Honorary Assistant) delivered a public lecture on February 21, in which he dealt with the light thrown on the determination of the constants of the motion of the Sun and the Moon by Greek and Chaldæan texts published since 1900, and directed particular attention to the work of the Chaldæan astronomers Naburianos and Cidenas. He has also published in conjunction with Professor Langdon and Herr Schoch a work in which the Venus observations of the reign of the Babylonian king, Ammizaduga, are discussed and identified. The calendar as it existed under the first dynasty of Babylon is reconstructed in the light of the astronomical observations and contract tablets, and a system of historical chronology consistent with the astronomical data is proposed.

Norman Lockyer Observatory, Salcombe Hill, Sidmouth.
(*Director, William J. S. Lockyer, M.A., Ph.D., Major* (*late R.A.F.*).)

The 9-inch Kensington Prismatic Camera has been in regular use throughout the year, for the purpose of photographing the spectra of some selected stars showing bright hydrogen lines. A camera has been made fitted with a Zeiss triplet lens of focal length 50 cm. working at $f4{\cdot}8$, and placed between the tubes of the 9-inch and 10-inch telescopes of the Kensington instrument. This is intended mainly for the photography of star regions or comets. The 12-inch McClean prismatic camera has also been in regular use, chiefly in the routine photography of B-type stars. During the year there were 123 fine nights, on 119 of which successful observations were made. This is better than the previous year (97 nights), but is still slightly lower than the average annual number of fine nights. The numbers of negatives secured with the Kensington instruments were: 136 with the 9-inch prismatic camera, 10 with the Dallmeyer doublet, 14 with the Zeiss-triplet, and 15 with the fixed meteor camera. With the McClean 12-inch prismatic camera 232 negatives were secured.

Work has been continued on bright hydrogen-line stars, an account of which has been published in the *Monthly Notices*, **88,** 683. The work on spectroscopic parallaxes has also been continued. The parallaxes of 125 B-type stars have been published (*M.N.*, **88,** 175), and also a note on a correction to spectroscopic parallaxes in general, arising from the presence of spectroscopic binaries (*M.N.*, **88,** 695). A wide absorption band found to be present in some B-type stars and previously noted by Shapley has also been discussed (*M.N.*, **89,** 127).

Mr. H. W. P. Richards, who had been appointed research student in 1927, left the Observatory on April 28; he was succeeded by Mr. E. G. Williams, who worked at the Observatory from May 19 to October 5.

The number of visitors who attended during the year was 305.

The twelfth annual general meeting of the Norman Lockyer Observatory Corporation was held in London on June 7.

Stonyhurst College Observatory.
(*Director, Rev. E. D. O'Connor, S.J.*)

The meteorological, magnetic, and seismological records have been carried on as usual, and the results forwarded to the official centres.

The 07·00 G.C.T. meteorological data have been received regularly every morning on the new wireless set, a daily weather chart has been prepared, and a daily weather forecast for the surrounding districts has been supplied to an evening paper, the forecast appearing in the mid-day issue.

A Dines anemometer is being erected (1929 January 13) to supplement the Robinson Cup anemometer already in use.

Observations of the solar surface were made on 269 days and include 275 drawings. Of these 233 are complete, showing all spots and faculæ; of the remaining 42, 13 are complete for spots. The mean daily spotted area (in units $\frac{1}{5000}$ of the disc) works out at 7·19 as compared with 5·15 in 1927 and 5·33 in 1926. No spots were visible on May 19 and 20.

Synoptic charts of the Sun have been prepared, showing all the spots and faculæ on the solar surface visible at Stonyhurst during each rotation. The dates (and times) on which the several meridians were central are indicated, as also the magnetic character for each day, and a miniature of the horizontal force trace. A comparison of solar and magnetic disturbances can thus be rapidly effected. It is hoped that it may be found possible to publish these regularly.

In determining the monthly base line values of the horizontal force magnetograph this year, a marked seasonal variation was noted, with a minimum about February and a maximum in August, the range being about 40 γ. Inspection of the values for the two previous years showed similar but less regular and less marked variation in each case. The variation is almost certainly attributable to temperature changes in the underground magnetic chamber. Further investigation of the matter is in progress.

The Director and Father Rowland attended the meeting of the International Astronomical Union at Leiden in July.

Lectures to various Societies on astronomical and meteorological subjects have been delivered by the Director, Father Rowland, and Mr. Ward.

Dominion Observatory, Ottawa, Canada.
(*Director, R. Meldrum Stewart.*)

Meridian Work and Time-Service.—Observations on the meridian circle programme were continued during the year. There were obtained 2150 observations of stars, 38 of planets, and 105 of the sun, on 178 observing days. The time-service was maintained as in previous years, without material change. Wireless time-signals were received regularly from Rugby, Annapolis, Bordeaux, and Nauen, all except the last being usually recorded automatically as well as by coincidence by extinction.

Time-signals were broadcast daily at 3 p.m., except Sundays, through the Ottawa radio station CNRO on concert wave-length, and through the Observatory station on a wave-length of 52·5 metres.

Solar Physics.—About 450 nine-strip spectrograms of the sun's limbs, midway and centre points, including standard iodine comparison spectra, were secured at λ 5600. A similar number of spectrum measurements and computations were made. The photographic recording of sunspots was continued, 130 plates being secured. An instrument for mechanical determination of the heliographic positions of points observed spectroscopically or by direct photography was constructed in the Observatory machine shop; this comprises a graduated metal sphere, a position circle, and a graduated rectangular frame-work for reading positions.

The 15-Inch Equatorial.—Radial velocity work was continued on bright Cepheids, spectroscopic triple systems, and on ϵ Aurigæ, which was passing through the eclipse stage of its twenty-seven year cycle. In all, 230 spectrograms were obtained. Mars was observed visually during its opposition and several sketches of markings were made. Curves of variation of ionisation and band intensity were obtained from an analysis of spectra of η Aquilæ made with a Moll thermopile microphotometer at McGill University. Minor alterations were made in the photo-electric photometer, and 92 observations were recorded during the year. The telescope was, as usual, used for the entertainment of visitors every clear Saturday evening.

Photographic Photometry.—A number of additional plates of comparison stars in Cepheid fields were obtained and the reduction work was carried forward. During the early part of the year work was continued on photography of Cepheid fields for the determination of light-curves; later, the observational work on this programme was discontinued pending the preparation of a new programme by the committee appointed at Leiden; reduction of plates already obtained is under way.

Seismology.—The number of earthquakes registered was the least for several years. Of the 311 recorded, 30 were reported to the Press and 31 by telegraph to Science Service, Washington. The major disturbances were: Mexico, February 18; Mexico, March 23; Peru, May 14; Mexico, June 17; Mexico, October 9. The seismographs at Ottawa, Saskatoon, and Halifax functioned regularly throughout the year. The short-period Wood-Anderson instruments at Shawinigan Falls and Seven Falls were also in continuous operation except for short periods of improper adjustment.

Terrestrial Magnetism.—Observations for declination, inclination, and horizontal intensity were made at 8 repeat stations and 3 new stations between longitudes 71° W. and 82° W., and latitudes 45° N. and 50° N. Six other stations were occupied in the region of Hudson Strait, declination, inclination, and total intensity by Lloyd's Method being observed at Port Burwell, Resolution Island, Cape Hopes Advance (2 stations), Wakeham Bay, and Nottingham Island.

Gravity.—Gravity determinations in Canada were restricted to a

single station—McGill University, Montreal. A new connection with Europe was furnished by occupation of stations at Greenwich and Potsdam: this connection, apart from the mere fact of increasing the accuracy of the tie between the continents, should throw light on the question of the reality of the longitude term in the gravity formula. A study was also made of modern European methods of gravitational and geophysical prospecting, with a view to the possibility of their application in Canada.

Publications.—One of the regular series of publications, vol. 9, No. 5, *A Study of Eta Aquilæ*, was issued during the year. Some fifteen articles by members of the staff appeared in various scientific journals.

Dominion Astrophysical Observatory, Victoria, B.C.
(*Director, J. S. Plaskett, F.R.S.*)

The observatory has lost the services of Mr. H. H. Plaskett, who left on leave of absence in February, resigned from the staff in August, and accepted a position at Harvard University. No appointment has yet been made to the vacancy. Mr. R. O. Redman of Cambridge joined the staff in August, accepting a temporary appointment as research assistant for a year. Mr. R. M. Petrie and Mr. P. M. Millman were temporarily employed as undergraduate assistants during the summer.

The observing weather, while better than in 1927, was below the general average, as only 1172 spectra were obtained in 1170 hours on 196 nights as compared with the ten-year average of 1590 plates in 1226 hours on 204 nights. On 107 nights 5 or more spectra were obtained, with a total of 979; while on 89 nights fewer than 5 plates were obtained, with a total of 193. It must be remembered, however, that in this total are more long-exposure spectra than formerly, as one observer took 46 nights to get 93 plates. A total of 1098 spectra were measured for radial velocity or other purposes. As in previous years, the observatory is opened every Saturday evening from 8 to 10 for visitors. The interest in and attendance at these open nights is well maintained. Including the day visitors, it is estimated that 35,000 persons visited the observatory during 1928.

The director has continued, in collaboration with Mr. Pearce, the observation and measurement of the B-type stars as in the past four years, and the programme of observation is now approaching completion. He was, however, absent from the observatory for six months owing to illness and to attending the meetings of the International Astronomical Union at Leiden and of the Astronomische Gesellschaft at Heidelberg. The revision of the velocities of the B stars and preparation of the material for the discussion occupied the time of the director for the remainder of the year.

Mr. W. E. Harper has continued the programme of A-type stars for the determination of spectroscopic absolute magnitude, and now has obtained spectra of nearly 1000 A stars for this purpose. Until

all stars on the programme are observed, however, he is determining the radial velocities, 330 spectra having been measured during the year. He has completed orbits of two A-type binaries with high eccentricities, Boss 4177 and H.R. 7338, and of one long-period K-type binary, Boss 3180. A preliminary orbit was also obtained for the double-lined binary A Persei of period 30·4 days and eccentricity 0·612. The amplitudes are so small, however, that higher dispersion spectra would be desirable to improve the orbit. A revision of a previous orbit of Boss 809 with a new period considerably improved the fit of the observations, halving the probable error.

Mr. H. H. Plaskett finally completed the MS. of vol. 4, No. 10, on the spectrum of Z Andromedæ before leaving for Harvard. He has since completed the measurement, reduction, and discussion of the intensities of the emission lines in nebular spectra obtained at Victoria. This is in the press as vol. 4, No. 14, of our publications.

Mr. J. A. Pearce has continued the observation and measurement of B-type stars in collaboration with the director. About 300 spectrograms were measured during the year, only about 100 more being required for completion, and considerable work was done in supervising computations (in preparation for the discussion of the B's). Two double-lined B-type binaries were completed during the year and published, while in two other double-lined B-type binaries of which orbits for the brighter component only had been published previously, measures of the secondary were obtained from additional spectra, the previous orbits improved, and the projected masses obtained. Progress was made and the period obtained for five other binaries, but more observations are needed to complete them. Two fast-moving stars, H.D. 6833, cG8, visual magnitude 7·10, radial velocity -- 257 km. per second, and the fastest-moving B star known, H.D. 78584, B3, visual magnitude 8·05, radial velocity – 136 km. per second, were discovered. Observations were begun of some of the fainter "*c*" stars for the rotation of the galaxy.

Dr. C. S. Beals has undertaken the observation, measurement, and discussion of spectra of all the Wolf-Rayet stars within reach at Victoria. The major part of the observation in the photographic region is completed, but more observations in the red end are required to enable the Wolf-Rayet spectrum to be more completely described. A number of different but self-contained criteria of excitation have been marked out, with which it is hoped to make a definite contribution to the classification of these enigmatic objects. The measurement of some grating plates of the spectra of oxygen and nitrogen obtained at the Imperial College has been completed, and considerable experimental work and design for a Littrow type of quartz grating spectrograph has been performed.

Mr. R. O. Redman, with our staff since August 1, has devoted a considerable part of his time to the reobservation of Y Cygni, the repeated remeasurement of the original plates and a recomputation of the old orbital elements. By a comparison of two orbits of this interesting star separated by nine years, it is hoped to obtain definite

information of the revolution of the apse. Some preliminary work was done on the D-lines in the hotter stars, but his major programme is that of Ko to K5 stars between visual magnitudes 7·0 and 7·5 near the galactic plane for the purpose of determining the galactic rotation for this limited class of giant stars.

Mr. S. N. Hill has continued his computation of the proper motion data for the stars of the B programme, and has computed in addition their galactic co-ordinates and the distance to the solar apex. Considerable other computing and tabulating work has also been performed.

Mr. R. M. Petrie and Mr. P. M. Millman assisted in the general observation and measurement during the summer months. Each obtained and measured in addition plates of spectroscopic binary stars, but no orbits were completed by them during the year.

There have appeared and been distributed during the year vol. 4, Nos. 4 to 11, while vol. 4, Nos. 12 to 14 are in the press, with others in preparation. In addition articles in astronomical periodicals by members of the staff have appeared during the year. An important part of the work has been the weekly meetings or seminars of the staff, fifty having been held in the year, during which important contributions in current literature are reviewed and the work of the observatory discussed.

Helwan Observatory, Ministry of Public Works, Egypt.
(Director, Mr. P. A. Curry.)

Time-Service.—The time-service was maintained as usual. No transit observations were made, the error of the standard clock, Shortt No. 1, being determined from the Bordeaux rhythmic time-signals.

The clock ran well throughout the year without any attention except that the battery was changed once. The original trouble caused by leakage of air into the clock case seems to have been completely cured.

Arrangements have been made to purchase one of the reversible transits from Greenwich, and it is hoped that this will be installed in the coming year and regular transit observations recommenced.

Reynolds Reflector.—The telescope was used on 47 nights through nine months of the year ; it was closed down during three months owing to the absence of the observer on leave. Fifty-four plates were exposed—36 on nebulæ, 15 test plates, and 3 on Comet Forbes. The comet was shown on the plates exposed on November 25 and 26, but accurate measurement was not possible.

General.—The usual meteorological, magnetic, seismological, and solar radiation observations were made.

At the request of Dr. G. M. B. Dobson, ozone spectrograms have been made daily during the latter part of the year, the instrument being lent by Dr. Dobson and the plates sent to him for development and measurement.

Nizamiah Observatory, Hyderabad.
(Director, Mr. T. P. Bhaskaran, M.A.)

Astrograph.—The number of photographs taken during the year was 203 ; out of these, 30 plates were for the determination of proper motions in the Hyderabad Astrographic zones, and 149 plates were secured in the regions of the old Potsdam zones, a portion of which it is proposed to complete at this observatory. Seventy-five plates were measured during the year, and the preliminary reductions have been carried on up to date.

Vol. vi. of the *Hyderabad Astrographic Catalogue* (Zone $-22°$) has been distributed. The MS. for vol. vii. (Dec. $-23°$) has been completed and a portion of the first proofs (up to R.A. 9^h) passed for press.

The Grubb 15-Inch Telescope.—The programme of work with this instrument has remained the same as in previous years. 1279 observations of variable stars were obtained during the year. The working list consists of 59 long period and 8 irregular variables (most of them having faint minima).

Miscellaneous Observations.—Forty-one occultations of stars by the Moon were observed :

Disappearances	35
Reappearances	6

Transit Instrument.—Observations with this instrument have been made as usual for determining clock corrections.

Seismology.—The Milne-Shaw seismograph registered 85 earthquake shocks during the year. The microseisms associated with the monsoon period were present in the records for 59 days. A second machine of the same type (Milne-Shaw) was received in 1928 December.

The meteorological observations and other miscellaneous routine duties have been carried on as usual.

Kodaikánal Observatory.
(Director, T. Royds, D.Sc.)

Photoheliograms were obtained on 333 days, calcium flocculi plates on 329 days, calcium prominence plates on 297 days, and Hα flocculi plates on 302 days. One calcium flocculi plate for each day was sent to the Solar Physics Observatory, Cambridge, as in former years.

Under the auspices of the International Astronomical Union, prominence and Hα spectroheliograms were collected from other observatories whenever complete observations were not possible at Kodaikánal, and the combined results were published in the half-yearly bulletins. Copies of 230 spectroheliograms for the years 1922–1925 were sent by request to the Meudon Observatory.

Commencing from 1928 January 1, daily character figures for solar activity as regards Hα bright flocculi and Hα dark markings were

communicated to the International Astronomical Union. The character figures for K bright flocculi from Kodaikánal plates are communicated by the Cambridge Observatory, combined with their own.

In consequence of the increase of speed in modern panchromatic plates it has been found possible to obtain spectroheliograms of prominences in hydrogen light in addition to that of calcium. Prominences were photographed in hydrogen light only occasionally in 1928, commencing from the month of November, since it was not known whether the increased speed of the plates was accidental to one consignment; but experience seems to warrant the inclusion of hydrogen prominences in the daily programme from 1929 January 1.

The highest prominence ever recorded at Kodaikánal was photographed on 1928 November 19, and had reached a height of 20′·9, or 910,000 km., when clouds intervened.

At the request of the Joint Permanent Eclipse Committee, the Director carried out tests for the best working conditions for neocyanin plates in Madras, where the temperature and humidity are similar to those obtaining in the 1929 eclipse, when these plates are to be used. It was found that even without the use of ice or fans the speed was not markedly less than in temperate climates, and that the commercial plates worked more cleanly than dyed plates, although the speed was not greater.

A Dobson's spectrograph for the determination of the amount of ozone in the atmosphere has been lent to the Observatory, and, since 1928 September 12, plates have been exposed daily whenever weather conditions permitted.

The Assistant Director's post, which has been vacant since 1923, was filled by the appointment, on 1928 December 17, of A. L. Narayan, M.A., D.Sc., F.I.P., formerly Professor of Physics in the Maharajah's College, Vizianagaram.

Union Observatory, Johannesburg.
(*Union Astronomer, Mr. H. E. Wood, M.Sc.*)

26½-*Inch Grubb Visual Refractor.*—The double-star survey of the Southern Hemisphere has been continued throughout the year. The year's work comprises :—

2678 measures of double stars (this includes the 9-inch measures),
567 new pairs discovered.

In connection with the programme of the survey, Dr. van den Bos and Mr. Finsen visited the Lamont Hussey Observatory at Bloemfontein in September, and Messrs. Jessup and Donner of Bloemfontein spent a week at Johannesburg in October. As the result of these conferences the two observatories co-operate fully in double-star research to avoid duplication of work, and weekly reports of work done are exchanged.

Observations of the satellites Enceladus and Mimas of Saturn were continued for Professor Georg Struve of Neubabelsberg, but, owing to

poor observing conditions, only 43 measures were obtained, as against 100 in 1927.

The year on the whole was characterised by a large number of clear nights, but by a very severe deficiency of nights of good definition.

Franklin-Adams Star-Camera.—During the year 876 plates were obtained with this instrument. The distribution of the plates was as follows :—

Minor planet regions and star maps . . .	139 plates.
Variable star regions	698 ,,
Comets	39 ,,

Many requests have been received from Europe for observation of minor planets, and an attempt is made, as far as possible, to obtain one or two observations of all planets out of reach of northern observatories. 258 accurately measured positions of minor planets have been forwarded to the Astronomisches Rechen-Institut, Berlin, for the year.

The instrument has been placed mainly at the disposal of Mr. H. van Gent of the Leiden Observatory for the photographic investigation of variable stars in the Southern Hemisphere. Mr. van Gent arrived at the Observatory on 1928 March 21.

9-Inch Grubb Refractor.—This telescope has been in use for observations of occultations of stars by the moon, eclipses of the satellites of Jupiter, and measures of the wider double stars. One night a week is set apart for visitors, the number recorded during the year being 1357.

Occultation of Stars by the Moon.—The programme of the last few years has been maintained. Predictions are made by a semi-graphical process for all stars for which accurate places are available, and disappearances are observed at the dark limb of the moon about the stage of first quarter. The observations are made with the 9-inch refractor, the Franklin-Adams Twin Telescope, and the 6-inch guider of the Franklin-Adams Star-Camera.

During the year 1928 the number of occultations observed was 171.

The results of the year's observations are as follows :—

	s	″
1928·1	11·6	6·4
28·4	11·6	6·4
28·6	10·8	5·9
28·9	10·9	6·0

The second column indicates the time by which the moon has arrived too early at any longitude, and the third column the distance the moon is ahead of its tabular longitude.

Further observations of occultations have been made by Dr. J. Moir, Auckland Park, Johannesburg, and Mr. G. E. Ensor of Pretoria. These observations have been reduced here and the results forwarded to Professor E. W. Brown.

Nova Pictoris.—On March 23 Mr. Finsen, on examining Nova Pictoris with the 26½-inch refractor as the result of a request from

Professor B. H. Dawson of La Plata that the diameter of the nova might be measured, found that the nova was a nebulous double star. His early observations are given in *M.N.*, **88**, 488 (1928 March). Later observations show that there are four components or nuclei in the image of the star, the brightest being in the centre, a somewhat fainter one following, a still fainter one south preceding, and a very faint, close one north, the existence of which is still considered doubtful. When the star came within reach of observation again in November no great change in its appearance was found.

The photographic image of Nova Pictoris, as obtained on plates taken with the Franklin-Adams Star-Camera, is extremely abnormal. The image is surrounded by a system of fairly sharp rings. Experiments with diaphragms over the lens indicated that the rings might be optical effects due to the fact that the light of Nova Pictoris is mainly concentrated in a few lines of the spectrum.

Comets.—Comet 1927 *k* (Skjellerup) was under observation from February 11 to April 28, Comet 1927 *h* (Encke) from March 20 to April 3, and Comet 1928 *b* (Forbes) from November 20 to December 24. All observations of comets are now made photographically with the Franklin-Adams Star-Camera. Although the scale of this instrument is small (180″ = 1 mm.), yet by giving the shortest exposure necessary to obtain a measurable image and by using Schlesinger's method of dependences in the reduction of the plate measures, it is considered that the observations are far superior in accuracy to those obtained with the 9-inch refractor. Also the period of observation is prolonged greatly by using the photographic method.

Time-Service.—Throughout the year, time has been taken from the Bordeaux rhythmic wireless time-signals at 8^h U.T.

The signals sent out from Rugby, England, at 10^h U.T. have also been received from their commencement. From 1929 January 1, the Rugby time-signals will be adopted as standards for the comparison of the Union Observatory clocks. An allowance of 0·027 seconds is made for the travel time of the signals.

Union Observatory Circulars, Etc.—During the year, Circulars Nos. 74, 75, 76, and 77 were issued, and the MS. of Circular No. 78 is in the hands of the Government printer.

Of the *Southern Star Maps*, 41 were issued with these Circulars, and the present state of this project is therefore :—

Maps already issued	319
Maps in hands of Government printer	35
Maps still to be prepared	202
Total	556

The distribution of the *Loose-leaf Catalogue of Southern Double Stars* was completed during the year.

Personal.—Dr. W. H. van den Bos was appointed Acting Chief Assistant as from 1928 January 1.

Adelaide Observatory, South Australia.
(G. F. Dodwell, Government Astronomer.)

During the year 1928, in addition to routine work described in previous reports, magnetic observations were made at 109 stations and sub-stations, principally on Yorkes Peninsula and the west side of Spencer's Gulf. Latitude and longitude observations were also carried out at Point Lowly, Whyalla, Port Lincoln.

A request was received from Professor Kimura, President of the I.A.U. Commission on Latitude Variation, for observations of latitude variation to be carried out at Adelaide in conjunction with La Plata Observatory, these two observatories being situated within one minute of latitude and separated by a large arc of longitude. This request has been brought before the South Australian Government, and it is hoped that favourable consideration will be given to the proposals made.

Melbourne Observatory.
(Director, Dr. J. M. Baldwin, Government Astronomer.)

The alterations to the 8-inch transit circle having been completed, work was recommenced with it during the year, the programme consisting of all stars contained in the list of Fundamental Stars published in C.T. for 1914 which culminate more than 20 degrees above the horizon. Each star is to be observed four times in each of the two positions of the instrument. The telescope is furnished with a hand-driven moving-wire micrometer by Troughton and Simms, and in other ways has been modified to bring it into line with modern practice. The Shortt clock, which serves as standard, gives very great satisfaction, the period showing a slow increase, but otherwise appearing most regular.

A few outstanding chart plates have been taken with the astrographic telescope, and the 8-inch equatorial has been regularly in use for observations of southern long-period variable stars.

During the year vol. ii. of the Melbourne portion of the *Astrographic Catalogue*, containing the rectangular co-ordinates of stars on plates with centres along $-67°$ and $-68°$, has been published, and some 2000 observations of variable stars have been printed in *Popular Astronomy* with others made by the Members of the American Association of Variable Star Observers.

The volume of Hourly Values of the Magnetic Elements at Toolangi in 1926 has been printed and distributed.

In January a new Milne-Shaw seismograph was installed, and since then has been in operation continuously. With the more sensitive instrument it has seemed worth while to circulate the results more widely than has hitherto been done. A series of seismological bulletins has been commenced, and these are distributed quarterly.

Mr. A. F. Bennett's Observatory, Leiston, Suffolk.

Observations of the sunspots and prominences have been continued, and the results communicated to the Solar Section of the B.A.A.

A number of plates have been exposed on various star fields in search of comets and other objects, using the two cameras which are mounted on the 6-inch Cooke equatorial. This telescope has also been employed for visual observations of Mars and other planets.

During the year fourteen occultations of stars by the moon have been observed under satisfactory conditions, and the results will be published in due course. In the meantime, separate reports of these observations, as they became available, have been passed to Dr. Comrie at H.M. Nautical Almanac Office for transmission to Yale for the use of Prof. E. W. Brown.

Wolsingham Observatory.
(*Rev. T. E. Espin.*)

The search for new double stars has been continued as in previous years with the 24-inch and 17¼-inch Calver reflectors, and the results have been communicated to the Society.

Starween Observatory, Worthing, Sussex.
(*Mr. A. M. Newbegin.*)

The usual programme of work on the prominences and sunspots has been carried out. The weather was very much more favourable than in the previous year, and the skies at Worthing have proved to be very transparent and the definition in every way suitable for solar work.

One hundred and thirty-eight observations for prominences were made, the mean daily frequency being 14·33. Their distribution was very uniform, but, as in 1927, there was a slight preference for the northern hemisphere and the eastern limb.

Metallic activity was recorded on 107 occasions—a much higher number than in the previous year. Fifty-three eruptions were seen on the eastern limb, but there were considerably more in the southern hemisphere than in the northern, the percentage south being 62·6. Many prominences were very active, a notable one being seen on the west limb on October 4, when 36 lines in the spectrum were affected.

There were also numerous occasions when large prominences were seen, many of them displacing the Hα line to the violet and red, sometimes simultaneously.

For sunspots 158 observations were obtained, yielding a mean daily frequency of 5·34. There were two high peaks of activity in June and August with a daily frequency of 6·43 and 6·94 respectively.

A large number of spots were examined in the Littrow-type spectroscope, constructed in the Observatory workshop during the summer,

and many showed striking vortical motion as evidenced by the movements of dark filaments seen in the C-line. The line was also brightly reversed over many spots, and there were several occasions when the *b* lines and D lines were affected.

During the year nineteen groups of spots were visible to the naked eye, and one day in September no less than three groups were seen in this way.

The results of these observations have been published quarterly in the Journal of the B.A.A.

Mr. B. M. Peek's Observatory, Solihull.

During the first part of the year the usual work of the Observatory was continued, but in the middle of September the instruments were dismantled, and the Observatory is being re-established at Solihull in Warwickshire.

For the time being, only the 12-inch reflector has been brought into use in the new locality; a revolving shelter, which is an improvement on the design employed at Herne, has been erected for it. It is probable that the 150 mm. Zeiss refractor will be in use again at Herne for some weeks during the summer.

The approximate position of the Solihull Observatory is

Long. $7^m\ 9^s{\cdot}8$ W.
Lat. $52^\circ\ 25'\ 18''$ N.

but a more accurate determination will be made later and communicated to the Society in the next annual report of the Observatory.

As before, physical observation of the major planets has been the chief item on the programme. Owing to the striking phenomena presented recently by Jupiter, most of the work has been concentrated on this planet, with the result that observations of Mars during the current apparition have suffered accordingly. Photometric observations of novæ and of a few U Geminid variables have been carried on, but continuity has been adversely affected by the move.

During the year 28 occultations of stars by the moon were recorded. The work of reducing these in duplicate has been undertaken and is well in hand; the results will be communicated to the Society.

The Rev. T. E. R. Phillips's Observatory, Headley Rectory, Epsom.

An important change was made in the instrumental equipment in the early part of the year. The 18-inch Green reflector by With, belonging to the British Astronomical Association, which for some years had been in the open, was mounted in one of the domes on the equatorial stand of the $12\frac{1}{4}$-inch reflector. The frame of the square wooden tube of the 18-inch was retained and suitably braced, but the panels were

removed so as to eliminate tube currents which are usually such a cause of trouble with reflectors. The work was carried out under the supervision of Mr. F. J. Hargreaves, to whom the mirrors of the 12¼-inch Calver telescope have been lent for use at his observatory at Kingswood. Under the new conditions the performance of the 18-inch exceeds all expectations.

During the earlier months of the year the usual observations of double stars and certain long-period variables were continued, but later the exceptional developments on Jupiter necessitated practically all available opportunities being devoted to observations of that planet. Fortunately the weather at the most important epoch proved extremely favourable, and at one period observations were obtained on as many as 37 out of 42 nights. A paper describing the progress of the changes to the end of October and the observations obtained in collaboration with Mr. F. J. Hargreaves and Mr. B. M. Peek has been communicated to the Society.

A number of observations were also made of Mars about the time of opposition, but the seeing conditions were then much less favourable.

The meteorological observations have been continued.

Dr. W. H. Steavenson's Observatory, West Norwood.

Observations were made on 97 nights during 1928. Included in this total are 26 nights on which work was done at the Royal Observatory, Greenwich, by kind permission of the Astronomer Royal, and three nights spent at the Leiden University Observatory, through the courtesy of Professor De Sitter.

Photometric work on the faint novæ has been continued throughout the year with the 6-inch refractor and other instruments. 115 observations of 8 novæ, including 84 of Nova Persei, have been made.

Physical observations of comets Encke and Reinmuth were made during February; and the planet Mars was observed as regularly as the very poor weather permitted during the last two months of the year.

Mr. H. G. Tomkins's Observatory, Dedham, Essex.

The equipment of this Observatory consists of a 24-inch Cassegrain equatorial reflector, the primary mirror of which has a focal length of 12 feet 7·25 inches. The convex secondary mirror increases the focal length of the Cassegrain to an equivalent of 47 feet, giving a lunar image at the focus of the combination of 5·25 inches diameter. The primary mirror is mounted in a heavy cast-iron cell hung on trunnions in a substantial cast-iron fork, which forms the upper end of the polar axis of the instrument, and thus enables the weight of the primary and its cell partly to balance the tube, secondary mirror, and flat. The primary mirror is not perforated.

The tube is of the open type, hexagonal in shape, with Russian pine

splines the full length of the tube at each angle, and bound together by rings of similar wood, the whole being braced up with No. 10 steel wire strained by motor bicycle fittings diagonally across each of the openings between the splines and rings. The tube is bolted to the rim of the cell by means of angle pieces forming feet, and the whole is quite rigid and light and needs no other support. In order to protect the inside of the tube from dust and stray light, a thin black calico lining is tacked on the outside. The use of the flat brings the focal image to the side of the tube at a convenient height from the floor for the camera and eyepiece. The instrument is clock driven and all moving parts are fitted with ball bearings. Both the primary and secondary mirrors were made by myself and have regular figures. The primary was left slightly under-corrected for temperature reasons, and the combination tested by Dr. Steavenson and myself was found to be regular in figure and slightly over-corrected. The latter may be due to change of temperature or to slight want of correction of the convex mirror. The performance of the instrument is good. I have to acknowledge the kind help and advice received by me in Calcutta from the officers of the Indian Survey Department and also the superintendent of the Indian Telegraph workshops, in designing and making the mounting. The $5\frac{1}{4}$-inch flat and eyepieces are by Messrs. Cooke of York. The instrument has been adapted to lunar photographic work, and 46 plates have now been obtained. The object aimed at is to take sets of photographs of particular portions of the lunar surface in several variations of lighting and perspective, with a view to more definitely elucidating their physical history. Up to the present time systematic drawings and other lunar work have been chiefly devoted to mapping the surface and measuring some of the heights and sizes of the moon's features. For the rest, lunar investigations have usually been highly speculative. The object of the present work is to reduce, as far as possible, this speculative element, and to obtain more definite and co-ordinated information regarding the formation and history of the lunar surface, in place of piecemeal and often vague descriptions and theories. A beginning has already been made and a series of plates obtained of the region in the neighbourhood of the Mare Nectaris, which it is hoped to deal with shortly.

There is also an $8\frac{1}{2}$-inch Newtonian reflector which is confined to visual work.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1928.

One hundred and forty-two planets were discovered in 1928, as follows :—

Month and Designation.	Day of Month.	Magnitude.	Discoverer.
Jan.			
BA	25	16·0	B1
BB	25	15·5	B1
BC	26	13·6	R
BD	26	13·7	R
BE	28	13·8	R
BF	28	14	R
Feb.			
DA	22	13·9	R
DB	23	14·0	R
DC	23	13·8	R
DD	23	14·0	R
DE	24	14	R
DF	24	13·8	R
DG	24	13·0	R
DH	24	16	W1
DK	25	16·2	W1
DL	25	15·5	W1
DM	25	15·8	W1
DN	25	13·9	R
DO	25	13·9	R
DP	25	14·0	R
DQ	25	14	R
DR	25	14	R
DS	25	13·7	R
DT	25	14·0	R
DU	25	13·9	R
DV	26	13·9	R
DW	26	13·7	R
DX	26	13·8	R
DY	28	14	R
DZ	28	13·8	R
DA_1	22	12·7	R
DB_1	25	13·8	R
DC_1	25	14	R
DD_1	28	13·9	R
DE_1	19	13·3	K
Mar.			
FA	16	14	R
FB	16	13·7	R
Mar.			
FC	17	16	W1
FD	17	15	R
FE	17	13·8	R
FF	17	14	R
FG	18	15·0	R
FH	18	14·0	R
FJ	18	14	R
FK	18	14	R
FL	18	14	R
FM	18	15	R
FN	19	13·6	R
FO	19	13·6	R
FP	16	12·4	SW
Apr.			
HA	20	16	W1
HB	20	16	W1
HC	24	15	W1
HD	24	14	R
HE	25	14·5	W1
HF	25	14·5	R
HG	18	12	W2
May			
JA	15	13·8	A
Jul.			
NA	10	13·5	W2
OA	17	13·8	N2
Aug.			
PA	11	14	R
PB	11	13·3	R
PC	11	12·5	R
PD	10	12·0	N2
PE	15	13·0	S2
QA	17	14·5	W1
QB	17	15	W1
QC	24	13	W1
QD	16	13·4	N2
QE	16	13·2	N2
QF	16	13·0	N2
Aug.			
QH	16	13·5	N2
QJ	22	13·5	N2
QK	22	13·4	N2
QL	22	13·7	N2
QM	..	14·0	N1
QN	19	11	G
Sept.			
RA	5	14·7	W1
RB	5	14·8	W1
RC	9	15·5	W1
RD	9	15·5	W1
RE	9	14	W1
RF	9	16	W1
RG	9	15·7	W1
RH	9	16	W1
RJ	9	13·4	W1
RK	9	13·7	W1
RL	9	13·2	W1
RM	12	16	W1
RN	13	16	W1
RO	13	15	W1
RQ	13	13	W1
RR	13	14	W1
RS	12	14·7	B1
RT	11	13·7	S2
RU	11	13·7	S2
RV	11	12·6	S2
RW	11	14·2	N2
RX	11	13·4	N2
RY	15	14	W1
RZ	11	13·2	S2
SA	19	13·5	D
SB	19	12·8	D
SC	17	13·4	A
SD	22	13·8	R
SE	22	13·7	R
SF	22	14·0	R
SG	22	15	R
Sept.			
SH	22	15	R
SJ	22	14	R
SK	22	14	R
SL	22	14	R
SM	23	14·0	D
SN	23	13·0	D
SO	23	13·0	D
SP	16	13·5	N2
SQ	16	13·5	N2
SR	16	13·6	N2
SS	19	12·5	S2
ST	21	13·0	N2
Oct.			
TA	14	12·7	SW
TB	6	13·5	D
TC	15	14·0	R
TD	15	13·7	R
TE	15	14	R
TF	15	13·6	R
TH	12	12·7	SW
TJ	13	13·0	D
TK	7	13·5	N2
TL	7	13·3	N2
UA	16	14·5	W1
UB	16	15	W1
UC	16	13·7	R
UD	16	13·6	R
UE	16	13·0	R
Nov.			
VA	5	13·2	S3
VB	9	12·7	B1
WA	17	12·2	S1
WB	20	14·5	W1
Dec.			
XA	9	13·0	R
XB	9	14·0	R
XC	13	12·5	V

The initials stand for: A = V. Albitzky, Simeis; B1 = W. Baade, Bergedorf; D = E. Delporte, Uccle; G = H. van Gent, Johannesburg; K = J. Kasansky, Moscow; N1 = K. Nakamura, Kyoto; N2 = G. Neujmin, Simeis; R = K. Reinmuth, Königstuhl; S1 = A. Schaumasse, Nice; S2 = Frau P. Shajn, Simeis; S3 = J. Comas Solà, Barcelona; SW = A. Schwassmann and A. Wachmann, Bergedorf; V = L. Volta, Pino Torinese; W1 = M. Wolf, Königstuhl; W2 = H. E. Wood, Johannesburg.

The following identities have been established: 270 = 1926 VG; 309 (missing since 1891) = 1925 BC = 1927 RA; 462 = 1927 CP; 463 = 1926 TC; 553 = 1927 WC; 573 = 1926 RF; 608 = 1927 QE; 722 = 1926 GR; 805 = 1928 QG; 814 = 1927 BA; 841 = 1928 DJ; 875 = 1926 RL; 883 = 1927 QK; 972 = 1926 XC; 981 = 1928 TG; 1022 = 1928 FQ; 1071 = 1910 JZ = Σ99 = 1924 RE (also two images found on 1914 plates) = 1927 YB; 1926 TD = 1926 VB; Σ87 = 1923 OY = 1925 BE (re-observed 1928).

The following identities are more or less probable: 220 = 1927 SD; 395 = 1926 SA; 684 = 1927 DC; 710 = 1927 CC; 810 = 1928 RV; 883 = 1927 QK; 982 = 1928 QF; 1058 = 1925 MA; 1059 = 1925 OA; 1926 CC = 1927 JB = 1928 TA.

Three of the long-missing planets, 220, 309, 315, have been recovered, but there is still a little doubt about 220. This leaves only four missing planets up to No. 399 inclusive.

The following planets have received permanent numbers: 1903 MC = 1926 RB = 1070; 1926 TA = 1072; 1923 OW = 1073; 1923 OY = 1074; 1926 SC = 1075; 1926 TE = 1076; 1926 TK = 1077; 1926 XB = 1078; 1927 AD = 1079; 1927 QB = 1080; 1927 QF = 1081; 1927 UC = 1082; 1928 BC = 1083.

Also 1927 CH has been numbered 933. The planet 1920 GZ, previously numbered 933, was found to be identical with 715, so the number 933 was free to be assigned to another planet.

The following objects have been struck out as erroneous: 1926 QB, 1928 LA, 1928 RP.

The following planets have been named: 763 *Cupido*, 954 *Li*, 955 *Alstede*, 969 *Leocadia*, 978 *Aidamina*, 1027 *Aesculapia*, 1037 *Davidweilla*, 1040 *Klumpkea*, 1071 *Brita*, 1074 *Beljawskya*.

There are some additional discoveries of planets to be recorded in years preceding 1928. The Königstuhl plates were re-examined, and two additional planets were detected on the 1904 plates, two on the 1909 ones, and seven on the 1915 ones; some of these were photographed on more than one day (*A.N.* 5560). The following were discovered at Tokyo: 1926 VK (previously supposed to be identical with 1018), 1926 XD (previously supposed to be identical with 942), 1926 XE, 1926 YA, 1927 WA, 1927 WB, 1927 WC.

Several of the more interesting minor planets were observed in 1928. These include *Aethra*, *Nestor*, *Priamus*, *Ganymede*, *Eros*. The last-named was under observation from July to September. The observations will be of use for rendering the elements of the next apparition (the near approach to the Earth in 1931 January) more exact.

E. de la Villemarqué, S.J., of Zo Se Observatory, was mentioned in the last report as having computed perturbations of 50 planets. He has extended his work to a second series of 50 planets in *A.N.* 5552.

A.N. 5557 contains a research by H. Osten on the perturbations of 447 *Valentine* by Jupiter. He finds the value 1/1047·57 for the mass of Jupiter from this research, and 1/1047·49 from a weighted mean between this determination and others. Newcomb adopted 1/1047·355.

A.N. 5580 contains a study of the secular perturbations of planets that are approximately commensurable with Jupiter, by K. Schütte. K. Hirayama contributes a note on the same subject to *A.J.*, 903. A. Wilkens had shown that a planet starting with $n = 598''{\cdot}26$, $e = 0$, would have $n = 609''{\cdot}1$, $e = 0{\cdot}1046$, after 17 revolutions of Jupiter. He expressed the opinion that it would remain in that orbit, but K. Hirayama concluded that it would return to its original orbit in about the same period and continue to oscillate between the two.

A.N. 5560 announces that C. Vick is investigating the orbit of 944 *Hidalgo*, the remarkable planet that travels from the orbit of Mars to that of Saturn. It has now passed its aphelion, and should be re-observed in two or three years. The last annual report stated that the planet 1927 BD travelled out to the orbit of Uranus; but it has been found that one of the observations used in obtaining that orbit was largely in error. The revised orbit has a moderate eccentricity and a period of about six years. A. C. D. C.

Report on Comets in 1928.

Four comets, discovered in 1927, were still under observation in 1928. Of these 1927 IX. (Skjellerup) and 1928 II. (Encke) were observed up till April, while 1927 IV. (Stearns) and 1927*j* (Schwassmann-Wachmann, now numbered 1925 II.) were still under observation at the end of 1928.

1928 *a* was found photographically by Herr Reinmuth in the course of the systematic work on minor planets carried on at Königstuhl. It was detected on a plate exposed on Feb. 22; subsequently images of it were found on plates of Jan. 26 (Barcelona), Jan. 29 (Königstuhl), Feb. 12 (Moscow). It proved to be a member of the Jupiter family with a period of 7·24 years; it was under observation till June, so the period is well determined.

M. Giacobini announced the discovery of a comet at the Paris Observatory on March 17; it was found visually, and was stated to be moving rapidly southward. Three rather doubtful photographic positions were subsequently announced: March 23 by Hoffmeister at Sonneberg, March 26 by Carrasco at Madrid, March 28 by Mineur at Paris. These indicate that the comet was almost stationary in declination, which disagrees with the discoverer's note of rapid southward motion; also it appears to be impossible to satisfy all four positions with any orbit, but it is doubtful which should be rejected. Provisional orbits are given in *B.A.A. Journ.*, **38**, 238, and in *Copenhagen Circulars*. The comet is considered too uncertain to receive a permanent number.

Ref. No.	Year and Number of Comet.	Name.	T.	ω.	Ω.	*i*.
				° ′ ″	° ′ ″	° ′ ″
153	1818 I.	Pons	Feb. 4·66	195 17 0	249 43 0	25 39 0
154	1818 II.	,,	Feb. 25·96901	112 20 19	70 27 14	89 44 48
259	1858 III.	Tuttle	May 2·94706	25 39 1	175 23 20	19 16 6
316	1873 VII.	Coggia-Winnecke	Dec. 1·93273	196 7 36	249 48 42	28 48 0
476	1907 III.	Giacobini	May 28·28563	35 59 13	167 48 34	13 33 56
505	1913 II.	Schaumasse	May 14·59776	52 58 23	315 3 39	152 21 31
552	1924 II.	Finsler	Sept. 4·35296	66 34 32	80 2 48	120 7 59
555	1925 I.	Orkisz	Apr. 1·51061	35 11 40	318 3 42	100 0 57
556	1925 II	Schwassmann-Wachmann	May 15·040	0 23 43	322 40 45	9 25 47
565	1925 XI.	Peltier-Wilk	Dec. 7·26739	126 7 13	140 34 36	144 36 22
572	1926 VII.	Reid	Dec. 30·58736	224 46 25	108 37 9	83 38 39
576	1927 IV.	Stearns	Mar. 22·8616	11 9 51	214 38 52	87 39 54
581	1927 IX.	Skjellerup	Dec. 18·18340	47 11 13	77 13 30	85 6 22
582	1928 I.	Reinmuth	Jan. 31·06983	8 39 0	124 56 6	8 3 46
583	1928 II.	Encke	P Feb. 19·6984	184 55 42	334 34 47	12 31 54
..	1928	Taylor	P Oct. 22·4	355 31 48	108 15 18	20 44 54
584	1928 III.	Forbes	Nov. 4·7549	195 38 16	250 13 37	28 55 55
..	1928	Tuttle-Giacobini	P Nov. 17·27	35 18 42	165 43 24	14 3 18
..	1929	Perrine	P July 24·752	167 11 37	242 26 12	15 43 40
..	1930	Daniel	P Apr. 7·516	6 4 54	70 8 21	19 50 21

Comet 1928 III., a fairly bright object of the sixth magnitude, was found on the morning of Nov. 19 by Mr. A. F. I. Forbes, an amateur astronomer of Rosebank, Cape Town, who is Treasurer and Librarian of the Cape centre of the Astronomical Society of South Africa. He had been sweeping for comets for some months with an 8-inch reflector of his own construction. The comet proves to be periodic, and identical with comets 1818 I. (Pons) and 1873 VII. (Coggia-Winnecke), whose identity with each other had been already suspected by Argelander, Weiss, and Schulhof, but was not previously capable of complete proof owing to the very short arcs covered by observations at the two former apparitions, which extended over four days and six days respectively.

A full discussion of the question of identity of 1818 I. and 1873 VII. by M. L. Schulhof is published in *Bull. Astron.*, III., IV. It now appears that the comet has made two revolutions since 1873, the mean period since 1818 being 27·69 years. It is not improbable that comet 1457 I. is the same comet. Celoria's elements from Toscanelli's rough observations are quite similar to the later ones; assuming 13 revolutions between 1457 and 1818, the mean period would be 27·77 years. No other comets have been found whose identity with this appears possible. The bright comet observed in China in 1162 was suggested, but if the Chinese record is correctly interpreted by Pingré as locating it in the region of Pegasus in mid-November, it cannot be the same.

Ref. No.	log q.	Period in Years or Eccentricity e in Hyperbolic Orbits.	Equinox.	Computer.	Reference.
153	9·87592	9·375	1818·0	L. Schulhof	*B.A.* III., 274.
154	0·078392	..	1818·0	J. Mrazek	*A.N.*, **232**, 177.
259	0·059016	6·01782	1858·0	A. C. D. Crommelin	*MS.*
316	9·87330	27·91	1873·0	L. Schulhof	*B.A.*, III., 180.
476	0·059681	4·12918	1907·0	A. C. D. Crommelin	*MS.*
505	0·163409	5419	1913·0	F. Zagar	*A.N.*, **233**, 15.
552	9·608671	1·001317 e	1924·0	V. G. Siadbey	*C.R.*, **186**, 736.
555	0·045164	1·000641 e	1925·0	N. Goryatschew	*M.N.*, **88**, No. 8.
556	0·741485	16·29875	1928·0	L. Berman, F. L. Whipple	*Lick Bulletin*, 394.
565	9·882848	1·000505 e	1925·0	F. Kepinski	*Bull. Acad. Polon. des Sci.*, 1927.
572	9·877793	1·008658 e	1927·0	A. C. D. Crommelin	*B.A.A.J.*, **38**, 187.
576	0·566406	289083	1928·0	Y. C. Chang	*A.J.*, 900.
581	9·246279	..	1927·0	A. C. D. Crommelin	*M.N.*, **88**, 596.
582	0·269599	7·2382	1928·0	L. Berman, F. L. Whipple	*Harvard card*, 65.
583	9·522011	3·286436	1928·0	L. Matkiewicz	*A.N.*, **231**, 11.
..	0·26301	6·75798	1928·0	G. van Biesbroeck, Y. C. Chang	*Harvard card* 73.
584	9·872148	26·0334	1928·0	H. E. Wood	*B.A.A. Circ.*, 69.
..	0·05575	5·3466	1928·0	A. C. D. Crommelin	*Observ.*, **51**, 354.
..	0·076883	6·58244	1929·0	F. R. Cripps	*B.A.A. Handbook*, 1929.
..	0·185565	6·81760	1925·0	,,	*MS.*

Taylor's comet was sought for in vain, in spite of the careful computation of the perturbations by Professor G. van Biesbroeck and Mr. Y. C. Chang. It divided into two nearly equal parts in 1916, and this, as in the case of Biela's comet, would seem to have been the first step to disintegration. Holmes's comet likewise evaded observation. It looks as if both of these comets might be written off as defunct.

Professor W. H. Pickering suggested in *A.N.*, **198**, 471, that the comets 1858 III. and 1907 III. were identical. The orbits of both have been redetermined: the observation of 1858 May 31 was rejected as being irreconcilable with the others. There is no doubt that 1907 III. is a comet of short period, but as it was observed for only 11 days and was ill-defined, so that the observations are not very precise, the period is subject to considerable uncertainty. A study of the perturbations by Jupiter in the interval 1858–1907 indicates that the most probable period of revolution is 49/9, or 5·44 years. This would give a near approach to Jupiter, with large perturbations, at the aphelion passage of 1904. A predicted orbit for 1928, based on this period and applying perturbations by Jupiter, is given in the orbit table. If this orbit was correct, the comet was too near the Sun to give any hope of detecting it. The hypothesis of 8 revolutions between 1858 and 1907 is not quite excluded; in that case the comet would be due to return about 1931.

Mr. F. R. Cripps has made it practically certain that the object

observed by Mr. Nakamura on 1922 Nov. 29 and Dec. 1 was not Perrine's periodic comet.

Mr. N. T. Bobrovnikoff publishes in *Lick Bull.*, 398, a study of the outward motion of matter in the tail of comet 1908 III. (Morehouse). He finds evidence of repulsive forces equal respectively to 88 and 151 times the gravitational force. He notes that these are both approximate multiples of 22, and that 151 is the repulsive force calculated for the CO^+ molecule by Baade and Pauli.

The strongly hyperbolic character of the orbit of comet 1926 VII. is worthy of note. Dr. R. T. A. Innes also drew attention to it. The orbit given in the table is not definitive, but it is amply sufficient to prove the fact that the eccentricity was considerably above unity.

Popular Astronomy for April contains an article by Dr. C. O. Lampland on radiometric observations of Skjellerup's comet, 1927 IX. Observations could be made in full daylight, different screens being used to isolate different regions of the spectrum. When the comet was nearest to the Sun the infra-red radiations increased and bright sodium lines appeared : these are frequently seen in the case of comets that approach the Sun closely.

The final paragraph in last year's Report (p. 299) needs correction. Only *one* Memoir appeared : the error arose through my coming across references to it under slightly different titles. A. C. D. C.

Double Stars.

Before Dr. Innes retired from the directorship of the Union Observatory, Johannesburg, he saw the completion of the loose-leaf Catalogue of Double Stars South of − 19°. In this compilation he has been specially assisted by Dr. Van den Bos and Mr. B. H. Dawson. The value of this catalogue should be great to double-star observers in the Southern Hemisphere, who are very active at present. It is true that the catalogue will have to be revised when the survey at present being carried out at Johannesburg and Bloemfontein is completed, but it will greatly help in this survey.

Dr. Aitken reports that on June 1 about two-thirds of the work of preparing the printer's copy of the Extension of Burnham's General Catalogue of Double Stars had been completed. It is hoped that the whole will be ready before the end of 1929.

The past year has seen the issue in a collected form of all Dr. W. Doberck's double-star measures. Dr. Doberck began observing in 1874 at Markree Observatory, Ireland, and, except for a break of twelve years towards the end of last century, has since carried on double-star work in various parts of the world. The observations have been made with instruments of relatively small aperture, but many of the measures are of fairly close pairs. The measures originally printed in the *Astronomische Nachrichten* have been published as vol. 7 of the Astronomische Abhandlungen of the *A.N.* There are in all 133 pages, and each page contains about 100 observations.

Measures and New Pairs.—Dr. Van den Bos has collected in a volume, published in the *Leiden Annals*, all his measures of double stars made at Johannesburg with the 26½-inch and 9-inch refractors from 1925·6 to 1928·2. The industry of the observer, as well as the excellence of the atmospheric conditions, is indicated by 4321 measures of 1754 pairs in 2½ years. The search for new pairs is being carried on systematically to magnitude 9·0 of the C.P.D. scale (about 10·1 Harvard photographic scale), while at the same time known pairs are being remeasured. It is found that one star in sixteen is double, and rather more than half of the double stars have not previously been observed as such. Dr. Van den Bos has now published details of 1405 double stars discovered by himself, the lists during the past year being published in *B.A.N.*, 153 (sixth list), B 927–1087; *B.A.N.*, 155 (seventh list), B 1088–1262; and *B.A.N.*, 163 (eighth list), B 1263–1405. Full co-operation in the search for new pairs exists with the Lamont-Hussey Observatory in Bloemfontein.

In publications of the Observatory of Tartu (Dorpat), Mr. Öpik has published measures made with the Zeiss refractor of some 600 double stars. The pairs are wide up to 32″. Many of them have bright primaries and faint companions. The purpose of these observations is classification into physical pairs and optical pairs, which is generally possible if the brighter star has a reasonable proper motion.

At the Leander McCormick Observatory, Professor Olivier has made many measures of double stars, both visually and on photographic plates. In *A.N.*, **233**, 393, he gives the results for 135 stars observed visually, mostly of fairly close and recently discovered double stars, and for 222 stars observed photographically.

Other measures of double stars published in various periodicals are indicated by the following table :—

Author.	Reference.	No. of Stars.	Notes.
Aitken, R. G.	*P.A.S.P.*, **40**, 355	1	A 770.
Alden, H. L.	*A.J.*, 913	1	α Centauri.
Armellini, G.	*A.N.*, **232**, 431	25	Wide.
Baize, P.	*Journ. des Obs.*, **11**, 46	161	Mostly wide.
Barton, S. G.	*A.J.*, 906	50	Oxford Ast. Cat.
		114	,, New and faint.
Berman, L.	*A.J.*, 895	72	Misc.
Espin, T. E. and Milburn, W.	*M.N.*, **88**, 185	55	New Es.
		41	New M.
Fatou, P.	*Journ. des Obs.*, **11**, 76	154	Misc.
Gauchet, P. L.	*Journ. des Obs.*, **11**, 112	22	Photographic, faint.
Manson, E. S.	*A.J.*, 910	24	Well known.
Marriott, R. W. and Pitman, J. H.	*A.J.*, 896	67	Photographic.
Phillips, T. E. R.	*M.N.*, **88**, 183	77	Σ, etc.

Orbits.—In *A.J.*, 893, Messrs. J. J. Nassau and P. D. Wilkins have discussed the graphical determination of the orbits of binaries in which the time element is fully used, and the drawing of the apparent ellipse is avoided. The method is specially suitable when the eccentricity is small. As an example the orbit of 70 Ophiuchi is deduced.

In *A.N.*, **233**, 217, T. Vahlen has given an analytical method for orbit determination from 7 observations.

Professor Crawford has discussed geometrically the determination of the elements of an orbit seen edgewise (*L.O.B.*, 403).

A new orbit for Procyon has been deduced by H. Spencer Jones, *M.N.*, **88**, 403. He has used meridian and spectroscopic observations as well as micrometric observations. The new orbit explains the difficulty of seeing the companion at present, but not the difficulty in the years immediately after 1910.

Other orbits published are :—

Star.	Authority.	Reference.	P. Years.	*a.* "	*e.*
13 Ceti	Maggini	*A.N.*, **233**, 97	6·895	0·247	0·816
ζ Her.	Silbernagel	,, ,, 145	34·417	1·349	0·455
μ^1 Her.	,,	,, ,, 257	43·02	1·287	0·18

Maggini's orbit for 13 Ceti is based on interferometer measures. The shape of the orbit is somewhat different from Aitken's based on ordinary measures, but the period and semiaxis are changed very little. The orbit of ζ Her. has been computed by Silbernagel for 3 different revolutions.

Miscellaneous.—The subject of dynamical parallaxes has been discussed by R. O. Redman in *M.N.*, **88**, 33, and by H. N. Russell in *A.J.*, 897. Both use the mass-luminosity law to give the last equation required to make the parallax determination without assuming a mass. Russell has entered fully into the statistical determination of the constants of the formulæ when only a small arc is observed. He finds, from binaries with large parallax, a correction of + 0·50 to the absolute magnitudes of Eddington's formula. For double stars with good orbits he finds an error of only ± 5 per cent. in the parallax, while for physical pairs showing motion the error varies from ± 23 per cent. for faint dwarfs to ± 28 per cent. for ordinary giants. Redman discusses the motions, luminosities, and masses of actual systems and finds additional support for the mass-luminosity law.

In five papers in *B.A.N.*, 151–154, Dr. E. A. Kreiken has discussed statistically double stars in the Greenwich, Potsdam, and Vatican Astrographic Catalogues. The distribution is considered for different values of m and Δm and relative to the galaxy.

Dr. Van den Bos has discussed in *B.A.N.*, 136, the reliability of interferometer and photographic measures. J. J.

Variable Stars.

The most prominent characteristic of the year's work on variable stars has been a falling off in the number of hypotheses of variation and a concentration on the accumulation of data. The statistical investigations appear to be particularly significant, and it seems advisable to present them (with the exception of those dealing exclusively with a single type of variable) under a separate heading. The remaining work has been classified in the usual way.

Statistical.—Two independent investigations point to the conclusion that an unexpectedly large proportion of variable stars are of the eclipsing type. W. Baade (*A.N.*, 5548) has classified the variables found in two Milky Way fields, situated in Sagitta and Cygnus respectively. He finds the following distribution among the several types.

	Sagitta Field Per cent.	Cygnus Field. Per cent.
Eclipsing variables	48	51
Long-period ,,	20	18
Cepheid ,,	7	15
Irregular ,,	10	10
Other ,,	2	2
Unclassified ,,	13	4

No explanation of this remarkable result is offered. H. H. Swope, however (*Harv. Bull.*, 857), in a report on 224 new variable stars (of which few are definitely eclipsing binaries) in a much larger field in Scorpio and Ophiuchus, compares the distribution of magnitudes with that among Baade's stars. It is clear that Baade's relatively high proportion of eclipsing variables is not the result of his finding fainter stars. Miss Swope attributes it to the greater thoroughness with which he has examined his fields, but suggests that it might possibly indicate a special concentration of eclipsing variables in Cygnus and Sagitta.

Almost simultaneously with these papers, C. Hoffmeister (*A.N.*, 5553) reports the results of a somewhat detailed investigation of a field of about 46 sq. degrees centred at 3 Lacertæ. Variability is established for 50 stars down to the approximate limit of magnitude 15·5, forming a surprisingly large proportion of one in every 1000 stars regarded as coming within the range of the method of observation. If this region is typical, the zone between galactic latitudes + 5° and − 5° would contain 4000 variables brighter than magnitude 15·5. The classification of the variables is as follows :—

β-Lyræ type . . .	1	Semi-regular . . .	7
Eclipsing variables . .	15	Irregular . . .	6
Cepheids	2	Uncertain . . .	4
Long-period variables . .	14	Unknown . . .	1

The proportion of eclipsing variables (30 per cent.) is again high; the *Katalog und Ephemeriden* for 1927 gives a percentage of 7·5 Algol

stars out of a total of 2906 variables. An irregular space distribution of the different types is possible, but it is regarded as much more likely that the explanation of the result is to be found in the exceptionally systematic character of the present investigation. Many eclipsing variables must remain undetected in a cursory examination owing to the approximate constancy of light over the greater part of the period. An attempt is made to estimate the degree of completeness of the investigation by evaluating the proportion of new discoveries to re-observations of previous ones on the last plates taken : for a complete examination this proportion should approximate to zero. It is found that the average for the last three plates is about $\frac{1}{2}$, from which it is concluded that the survey is far from complete. The proportion of stars which are variable is therefore probably still larger than that found, and it is further regarded as probable that the proportion of Algol variables, and that of stars with periods less than one day, should be increased. The latter stars are liable to have been overlooked because of the rather long exposure time, during which any variation of brightness would of course be unrecorded. The field investigated is considered as probably the most thoroughly examined region of the heavens from the point of view of statistics of variable stars ; it follows, therefore, that for no region are the total or relative numbers of these stars accurately known. The following threefold programme is suggested : (1) A determination of all variables in the sky brighter than the 12th magnitude ; (2) an extension of the determination to stars brighter than the 16th magnitude at maximum, in limited regions of about 50 square degrees ; (3) an extension to the 19th magnitude for fields of about 1 square degree. Incomplete investigations are to be deprecated, as introducing confusion rather than adding to knowledge. In particular it is urged that an announcement of variability of a star should always be accompanied by a statement of the class of variable to which the star belongs.

The reality of the high proportion of eclipsing variables suggested by Baade and Hoffmeister is questioned by I. Yamamoto (*A.N.*, 5596), who recalls that in an earlier study of the same question, based on the stars recorded in the B.D., Co.D., and C.P.D., he reached widely differing conclusions. The data, however, were "weighted" by a process which is not stated. He reproduces the figures obtained, together with the results of a similar but recent analysis of the variables in Prager's *Katalog und Ephemeriden*. The four catalogues show a fairly consistent distribution among the various types, viz. :—

Type of Variable.	B.D. Variables.		Co.D. Variables.*		C.P.D. Variables.*		Prager's Kl. Veröff. 3.	
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
Long Period	261	45·7	72	53·2	28	32·2	858	49·9
Eclipsing	108	18·9	27	20·0	14	16·0	297	17·3
Cepheid	106	18·6	12	8·9	32	36·8	295	17·2
Irregular	96	16·8	24	17·8	13	14·9	270*	16

* Somewhat uncertain.

The probability of discovery of eclipsing variables, in so far as it depends on geometrical conditions, is discussed by H. I. Gramatzki in *A.N.*, 5575, the "probability" being defined as the ratio of the region of space from which an eclipse in a double-star system would be visible, to the whole space around the system. An expression for the probability is derived in terms of the period of revolution, the density of the primary, and the ratios of mass and density of the components. It is shown that the ratios of mass and density have very little influence on the value of the probability, so that in applying the expression to observation the term involving them can be neglected without introducing errors in excess of those to which actual determinations of those quantities are subject. A table is then prepared showing the value of the probability for various periods and densities of the primary, and the discoveries of eclipsing variables in 1925 are discussed in relation thereto. It is shown that although the maximum number of discoveries corresponded to a mean period of 1·825 days, the probable number of actually existing stars of this type (obtained by dividing the number discovered by the probability) would have a maximum for a mean period of 7·30 days for all values of the density of the primary greater than 0·005 times the density of the sun. It is concluded also that the 176 discoveries during that year correspond to an actual number between 1585 and 3170.* Cepheids also are treated in the same way, on the hypothesis that their discovery similarly depends on the position of the observer in space. It is shown that while the actual discoveries were a maximum for a period of 0·365 days, the corrected values give a maximum, as for the eclipsing variables, at 7·30 days.

Concerning other types of variables, two papers call for mention. T. Araki (*Jap. Journ. Ast. and Geophys.*, **5**, No. 3, p. 1) considers periodic variable stars (other than eclipsing variables) in relation to their periods and the quantity, $\epsilon = \frac{M - m}{P}$, where $M - m$ is the interval of *time* between a minimum and the following maximum, and P is the period. He shows that Cepheids fall into three groups having different period ranges, viz. periods up to about 0·7 days, from about 2 to 7·5 days, and from 7·5 to 50 days. In each group there is a regular progression of ϵ with period such that as the period decreases, ϵ increases, tending to a value $\frac{1}{2}$ (*i.e.* a symmetrical light-curve) for the shortest periods. The same characteristics are shown by the long-period variables, which form a single group. It is therefore concluded that the periodic variables belong to four groups having similar characteristics.

Photo-electric observations of brightness of late-type stars are reported by J. Stebbins and C. M. Huffer (*Proc. Nat. Acad. Sci.*, **14**, 491).

* It would appear that the results indicate the number of *double* stars corresponding to the eclipsing variables discovered. The author seems to have ignored the fact that the designation "eclipsing variable" can be applied only to stars having a certain space relation to the observer. It may be remarked also that the investigation presupposes a random space distribution of the planes of double-star orbits.

164 M-type stars north of declination − 10° and brighter than visual magnitude 6·0 have been examined for variability and compared with 165 K-type stars. The results are shown in the following table :—

Range of Variation.	G5–K5.	Mo.	M1.	M2.	M3.	M4.	M5.	M6.	Total. M.	Total. K.
m m										
0·000–0·069	165	29	26	22	16	1	0	0	94	165
0·070–0·099	..	3	1	8	7	2	0	1	22	
0·100–	..	2	2	9	8	11	7	2	41	
Visual variables (0·5–)	..	0	0	2	1	1	2	1	7	
Totals	165	34	29	41	32	15	9	4	164	165

The stars in the first row are regarded as probably constant, the small variations observed being attributable to experimental errors : those in the second row are " suspicious," with a probability of actual variation, while those in the other two rows are certainly variable. Forty of the stars in the third row are here reported as variable for the first time ; those among them of larger range are separately tabulated. Attention is directed to the fact that none of the K-type stars is even suspected of variation, while among the M-type stars there is a distinct tendency to variability with increasing redness. It may be said that any distinctly red star (*i.e.* of classes M4–M6) is almost certainly a variable to the extent of 10 per cent. or more. All the stars are giants, and there is an increasing tendency to variability with increase of brightness. Either extreme luminosity or extreme redness seems to go with variability. The variation would be expected to be irregular. Although no exactness can be claimed, it seems clear that for about half of the stars, any period which may characterise the variation must be greater than 100 days ; for two or three it is less than 50 days, and for the remainder it is doubtful.

Novæ.—The discovery of a nova in Taurus (Nova 100, 1927, Tauri) on 1927 November 18 is reported by A. Schwassmann and A. Wachmann (*A.N.*, 5560). The spectrum, of which details and reproductions of photographs are given, is typical.

Changes in the spectrum of Nova E. L. Aquilæ, 1927, between 1927 August 23 and October 30, when the nova was in the " nebular " stage of its development, are described, with diagrams and curves, by G. Shajn and W. Nikonoff (*A.N.*, 5581). Twelve objective prism spectra of small dispersion were obtained. Particular attention is given to the lines of hydrogen and ionized nitrogen and the green nebular radiations, and the variations of brightness of these lines are estimated and tabulated in stellar magnitudes at various times during the period of investigation. The phenomena were very similar to those shown by Nova Geminorum, 1912, in the period March 22–May 10.

Nova D.O. Aquilæ, discovered by M. Wolf in 1925, has been subjected to photometric examination by H. Vogt (*A.N.*, 5559). The

long duration of the maximum phase and the slow subsequent changes of brightness are similar to those of Nova Pictoris.

The latter star is reported by W. S. Finsen (*M.N.*, **88**, 488) as having been nebulous and apparently double on 1928 March 23. J. S. Paraskevopoulos (*Harv. Bull.*, 856), however, reports that several photographs taken about 1927 November at the Boyden station of Harvard College at Bloemfontein show a ring surrounding the nova—rather narrow and well defined, of not very high density, and of small diameter. Further observations of the ring are recorded in *Harv. Bull.*, 859. The abnormal phenomena shown by Nova Pictoris are discussed by A. C. D. Crommelin in *Obs.*, **51**, 155. He gives reasons for suspecting that the star has a large parallax, and was consequently an extreme dwarf before outburst—possibly a white dwarf.

A speculation that novæ in general are explosions of white dwarfs is made by H. Gehne in *A.N.*, 5569. He suggests that owing to a failure of the internal energy stream the electrons and nuclei of the star tend to recombine and return to a normal density, thus causing sudden expansion.

Another possible cause of the origin of novæ is proposed by M. C. Johnson (*M.N.*, **88**, 380), who considers the consequences of interaction between a faint star and the gaseous interstellar matter postulated by Eddington. He finds that the star by gravitational attraction would gradually acquire an accretion of matter which would form a new covering. This would fall into the photosphere, causing a rise of temperature and an accelerated and unstable rise in the absorption coefficient. After a long period a breach would occur in the accretion layer, allowing a sudden reduction of the absorption coefficient to its normal value. The process would be accompanied by a great outburst of radiation, which would account for the appearance of a nova. By balancing the energy acquired during accretion with the average energy of outburst of a nova, it may be estimated that the accretion would proceed for about two hundred years before outbreak.

β-Lyræ Type and Eclipsing Variables.—In *M.N.*, **88**, 162, M. Blagg reports a continuation of her study of recorded observations of β Lyræ during intervals within the period 1877–1905. The previously discovered subsidiary wave of light variation (B) is again evident, with a period which, taken in conjunction with earlier results, indicates a gradual increase of period of the subsidiary wave similar to that of the main variation. Two periodic fluctuations in phase have been noted and others are suspected.

S. D. Tscherny contributes a note (*M.N.*, **88**, 482) on this work, in continuation of his previous investigation of the periodic changes of β Lyræ. A. Danjon, however (*C.R.*, **187**, 279), in an analysis of the photometric observations of β Lyræ, finds no confirmation of Miss Blagg's period B, which he regards as artificial.

Existing data for eclipsing variables are discussed by G. Shajn in *M.N.*, **88**, 213, with the object of determining general relations between the masses, luminosities, and spectra of the components. He reaches

the following conclusions : The mass-ratios, computed on the basis of the theory of radiative equilibrium, for 15 such stars which are known to be spectroscopic binaries, are in fair agreement with the observed values ; they decrease (*i.e.* the departure from equality increases) with increasing difference in brightness of the components. The discussion of 108 eclipsing binaries shows that the mass-ratio is closely connected with the spectrum of the primary, and tends towards unity with advancing type. The difference in surface brightness, or spectral class, of the components increases with difference in magnitude. The effective temperatures of the secondaries, deduced from the ratio of surface brightness, decrease with advancing type of the primary. The densities of the components increase with advancing type, the ratio tending towards unity, except for the B-type stars. The primaries belong to the main sequence of stars, but the data for the secondaries are contradictory. The computed effective temperatures, as well as the observations, show that the secondaries are of much later type than the primaries. The Russell-Hertzsprung diagram, if constructed on the basis of the luminosity-spectrum data for eclipsing binaries, would be of a very unusual character. These correlations are somewhat analogous to those found in double stars.

An attempt to estimate the distribution of matter in the components of eclipsing binaries from the rate of advance of periastron is made by H. N. Russell in *M.N.*, **88**, 641. The only star for which such an advance has been definitely indicated is Y Cygni (see *Harv. Bull.*, 856), and the investigation, assuming the star to be built on Eddington's model, leads to a surprisingly small degree of central condensation. It is suggested that an explanation may be found in Jeans's proof that, owing to " radiative viscosity," the inner portion of a star should rotate more rapidly than the outer layers. An exact allowance for this effect, however, would be difficult.

More than one observer has previously called attention to a dependence of the observed phases of eclipsing variables on the colour of the light in which the stars are examined. B. Okunew (*A.N.*, 5611) reports an investigation of Z Vul. and TX Her. with the object of testing this relation. He finds a variation of the times of minimum according to the following table, in which " visual " refers to observations without a colour filter :—

	Yellow *minus* Visual. min.	Blue *minus* Visual. min.	Blue *minus* Yellow. min.
Z Vulpeculæ	−12	+22	+34
TX Herculis	− 9	+ 3	+12

Maggini, using a larger range of wave-length, had previously found for " short waves *minus* long waves," a difference of phase of + 124·5 mins. for Z Vulpeculæ.

E. Hertzsprung's report on the observations of eclipsing variables made by him at Harvard (*B.A.N.*, 146) includes particulars of two remarkable stars. RZ Cancri (HD 73343) is a yellow giant (Ko) with the average density of such stars, and RU Centauri, a star with a β-Lyræ type of light-curve, has a period of 64·74 days.

Two other investigations of particular stars deserve mention. H. Schneller (*A.N.*, 5590) reports the elements of variation of the eclipsing variable RS Canum Venaticorum based on new observations of photographic magnitude and earlier spectroscopic data, from which it appears that the components of the star are respectively an F3 dwarf (vis. abs. mag. 1·93), and a K0 star lying between the dwarf and giant branches of the Russell diagram. The stars appear to radiate somewhat too copiously for their masses.

The other paper is a theoretical discussion by D. B. McLaughlin (*Pop. Ast.*, **36**, 569) of ϵ Aurigæ, an eclipsing variable with a period of 27 years and an eclipse duration of 2 years, including 1 year totality. The very puzzling spectroscopic phenomena shown by this star have led Ludendorff to suggest that the secondary is an elongated group of meteors which periodically eclipses the primary. McLaughlin proposes an alternative hypothesis that the secondary is a large, attenuated, approximately spherical, dark nebula, and that the primary is intrinsically variable. He suggests that R CrB is a similar object. Difficulties in the hypothesis are pointed out, and it is suggested that by combining it with Ludendorff's hypothesis, the most probable explanation may be obtained. Irregularities in the maximum light of this variable are discussed by H. Shapley in *Harv. Bull.*, 858.

Cepheids.—A new method of determining the elements of variation of Cepheids is described in some detail by G. Tiercy in *Osserv. e Mem. del R. Osserv. Astrof. di Arcetri*, **44**, 1, and a general programme of study of Cepheids is begun by its application to SU Cas. The method of investigation centres in the measurement of the breadths of absorption lines at different phases. In general, the breadths of the lines and the length of the continuous spectrum vary with the phase. If L is the maximum length of continuous spectrum (corresponding to maximum brightness), d is the difference between L and the length at another phase, y is the sum of d and the total breadth of all the absorption lines at that phase, and $x = \mathrm{L} - y$, then the ratio $\frac{y}{x}$, which is denoted by q, is taken as a new parameter whose properties are studied. The measurements from which q is determined were made with a spectro-comparator and reduced to a common exposure time. It is shown that the curve of variation of q throughout a period is identical with the light-curve. Separate consideration is given to the variation of the breadths of [H, K] and the hydrogen lines. The light (or q) curve is then considered in relation to the change of spectral type, and it is shown that the star exhibits a lag in changing its spectral type as the light changes. A theoretical discussion is given of the temperatures and pressures in the star's atmosphere, and of the changes of radius on the assumption of a pulsation. The colour index (I) is next derived in terms of radius and absolute visual magnitude, and checked by other determinations. It then appears that the maxima and minima of the I-curve precede the minima and

maxima of the light-curve, and, in fact, the maxima and minima of the I-curve coincide with the minima and maxima of temperature and latest and earliest spectral type, respectively. It is held that this is entirely a consequence of the variation of pressure, although a little later it is stated that the " velocity of change of spectral type " is a function simultaneously of temperature and pressure. On plotting I against q an ellipse is obtained, of which the major axis joins the points of maximum and minimum q (or light). (The duration of the ascending and descending branches of the light-curve is sensibly the same for SU Cas.) It is then obvious that for the same value of q the spectral type is later for the ascending than for the descending branch. In conclusion, an attempt is made to generalise the results by showing how, from the I/q-curve for one star, that for another can be obtained with a very small number of direct observations, and how therefrom all the elements and the phases of the light variation can be found. The method is later applied to determine the elements of T Vulpeculæ and X Sagittarii by determination of q (*Arch. des Sciences*, **10**, 107, 159).

W. Zessewitsch and B. Okunev, however (*A.N.*, 5596), criticise Tiercy's work on the ground that the dependence of the line breadth on the light variation of the star is not so simple as Tiercy assumes. According to the pulsation theory, the breadth depends on (1) the distribution of brightness over the disc; (2) the pressure changes in different layers of the atmosphere; (3) the probable rotation of the star. The last factor introduces a constant broadening. The first is shown to influence a change of breadth, depending on the pulsation, which has a period of half the light and velocity period. Since several observers have shown that the variation of line breadth has the same period as the brightness and velocity, the second factor must predominate. Tiercy, however, assigns to it the whole variation of line-breadth. Criticisms of details of Tiercy's investigation also are advanced. The writers conclude that Tiercy's relation between I and q is probably real, but is not so clearly established as his paper claims. The criterion which he suggests for the classification of the curves of Cepheids can be considered as having only an empirical significance, the generality of which should be a subject of further investigation.

A few theoretical papers have appeared during the year. In *A.N.*, 5604, M. la Rosa develops his ballistic theory of variable stars by considering the case in which the product kb $\left(k = \frac{\Delta}{c\tau_0}\right.$, where Δ = distance of star from the observer, c = velocity of light, τ_0 = period of revolution of star in circular orbit; b = ratio of tangential velocity of star to velocity of light) is much greater than unity. He finds that the light-curves predicted by the theory for stars in which this holds are completely analogous to those of variables of the U Geminorum and cluster types. A general consideration of the alleged divergence between the types of variability required by the ballistic theory and those observed is reserved for a further paper.

In *M.N.*, **88**, 502, J. J. M. Reesinck reconsiders the behaviour of the outer layers of a pulsating star, with regard to which he and A. S. Eddington had previously arrived at different conclusions (see *M.N.*, **88**, 323). Investigating the problem more rigorously than in his former paper, he arrives at a result in agreement with Eddington's.

The atmospheres of Cepheids are discussed also in two papers by T. Araki (*Jap. Journ. Ast. and Geophys.*, **6**, No. 1, pp. 1, 15), who calculates the changes of pressure which must occur there in order to correspond, according to the Saha theory, with the changes of spectral type and light, assuming that maximum light corresponds to the earliest spectral type and minimum light to the latest. He finds that it must be assumed that the pressure in a given layer is from ten to thirteen times as great at maximum light as at minimum. He shows also that there is a probable relation between the pressure change and the radial velocity. In the second paper he finds that the atmospheric pressure of Cepheids is smaller during negative radial velocity and greater during positive than that corresponding to the equilibrium condition. The curve of pressure change is approximately parallel to that of radial velocity, the distance between the curves being independent of the particular star considered. This relation, however, fails in the neighbourhood of maximum positive velocity. The pressure changes are in complete agreement with the dependence of radial velocity on level in the atmosphere as determined by Curtiss and Rufus (see Council Notes for 1926, p. 254, and 1927, p. 325).

The changes of radius of δ Cephei obtained by integration of the radial velocity curve are compared by D. O. Mochnatsch and E. V. Okunev (*A.N.*, 5590) with the values obtained from the formula: $\log r = 8{\cdot}52 - 0{\cdot}2M_b - 2 \log T$ (r = radius in terms of sun's radius; M_b = absolute bolometric magnitude; T = effective temperature). This formula is obtained by assuming that the star and the sun radiate as black bodies, and that for the sun, $M_b = +4{\cdot}8$ and $T = 6000°$. It is valid on the following assumptions: (1) that the star is spherical; (2) that there is a uniform distribution of temperature and brightness over the surface of the star; (3) that the black-body radiation laws hold for each phase of the variation; (4) that the distribution of brightness over the star disc is the same as for the sun. M_b is determined from the period-luminosity relation, corrected to the bolometric scale, and T is obtained independently from Hopmann's colorimetric observations and Shapley's spectroscopic observations. It appears that the amplitudes of the changes of radius derived from these two sources are in good agreement with one another, but are very much larger than the amplitude obtained by integration of the radial velocity curve. It is shown that part, but not all, of the difference can be accounted for by corrections to be applied to the curves, and that the temperature variations observed in δ Cephei are greater than those which Eddington's pulsation theory demands. The conclusions are drawn (1) that if the pulsation theory in Eddington's form is correct, the temperature changes given by Hopmann and other observers are considerably

greater than the true values; (2) that if the observed values are approximately correct, the above formula is not applicable, and an unknown term must be included, depending on a non-spherical shape of the star or other unknown factors.

A similar type of investigation is carried out by K. F. Bottlinger with respect to ζ Geminorum (*A.N.*, 5545). On the basis of photoelectric measurements of brightness and determinations of colour index, curves are drawn showing the variations of these quantities throughout a period, from which it appears that there is a slight but undoubted lag of the light-curve with respect to the colour curve. (Compare the similar result of Tiercy with respect to SU Cas. on pp. 373–4 of this note.) From the data thus obtained the apparent diameter of the star at various phases is calculated from the equation: $\log \rho = \text{const.} - 0{\cdot}2m + 2 \log \frac{c_2}{T}$ (ρ = radius, m = bolometric magnitude, and T = effective temperature). T is calculated from the colour index curve by Brill's relation, and m is determined from the light-curve by means of a special investigation. It is pointed out that the amount of the relative displacement of the two curves is so uncertain that the results can have only a provisional character. They indicate, however, a variation of radius of about 14·3 per cent. on either side of the mean. This corresponds to a value of 1,800,000 km. for $a \sin i$ of the hypothetical spectroscopic "orbit," from which is obtained a mean star radius of 12,600,000 km., a mean absolute brightness, $-0^m{\cdot}67$, and a parallax, $0''{\cdot}011$. Shapley's values, determined from the period-luminosity relation, are, for the latter two quantities, $-3^m{\cdot}4$ and $0''{\cdot}0024$. As a check the variation of radius has been determined also by numerical integration of the radial velocity curve. The curve of radius change obtained in this way differs in form from that given by the above equation, and is removed from it in phase by about one day, but the result is not conclusive because of the uncertainty of the colour index data. The amplitudes of the radius variation, however, shown by the two curves appear to agree (the paper is not quite definite on this point), and it is considered that the disagreement with Shapley's value is established. Unless the pulsation theory be abandoned it must be concluded that the radiation laws, although possibly applicable in the mean, are not fulfilled at individual phases. Existing data are insufficient to permit of a satisfactory detailed comparison between the curves obtained, and further investigations are being made.

The radial velocity of η Aquilæ forms the subject of a paper by F. Henroteau in *Pub. Dom. Obs. Ottawa*, vol. ix., No. 5. An average amplitude of 40 km./sec. is found from the lines of neutral atoms, while lines of ionized atoms give the value 50 km./sec. Rufus has found for this star a dependence of the radial velocity on the atmospheric level of the lines examined. His results were not confirmed by Jacobsen in a preliminary investigation, and Henroteau likewise finds no evidence for them.

In *A.N.*, 5551, F. Pavel describes a photographic determination of the period of WY Draconis, a star of RR Lyræ type, which had been

reported as having a period of less than two hours. He finds a period of 0·5889 day, while A. Brun (*Lyons Obs. Bull.*, **6**, 241 and **7**, 79) finds, from visual observations, a period of 0·5882 day. The visual amplitude is only half the photographic. The phase of increasing brightness is found by Pavel to occupy only 0·07 day.

RR Lyræ itself is the subject of a paper by R. F. Sanford (*Ap. J.*, **67**, 319). He reports changes in the period and radial velocity variation which are harmonised by the formula—

$$\text{Maximum light} = \text{J.D. } 2414856{\cdot}480, \text{ G.M.T.} + 0^{d}{\cdot}56681729E + 0^{d}{\cdot}121(10^{-4}E)^{2}.$$

Reasons are given for believing that the angle of periastron, the time of periastron passage, and the semi-amplitude of velocity variation, are varying.

The discussion between C. D. Perrine and P. Doig on the luminosities of galactic Cepheids (see last year's Council Note) is continued in *Obs.*, **51**, 160, 197, 292; and in *Journ. B.A.A.*, **38**, 255, Doig shows that the relative radiative outputs of Cepheids, calculated on the assumption that the squares of the periods are inversely proportional to the densities, agree well with observation when masses are adopted which correspond to seven times the Sun's mass for the Go star of period 3·9 days. This result is consistent with the period-luminosity curve of Shapley.

The study of the statistical properties of galactic Cepheids (see Council Note for 1927, p. 326) is resumed by J. Schilt in *Astron. Journ.*, 910. He gives reasons for believing that the Cepheids (*i.e.* stars having Cepheid-like light-curves with periods longer than those of the cluster-type variables and shorter than those of the Mira stars) form more than one group. A division is first made between stars of this type having periods respectively less and greater than ten days. The former are called " typical " Cepheids. A number of them show special properties which require that they shall be classified in a separate sub-group: they are identified with the *c*-stars, and have periods, as a rule, between 7 and 10 days. Of the other Cepheids, whether typical or not, only 3 out of 43 have periods between these limits. Among the typical Cepheids, the most frequent period is found to show a remarkable relation with galactic longitude of the kind which would be expected if the periods depend on the distances from the centre of the stellar system. The form of the relation leads to a value of 5600 parsecs for the distance of the centre of the stellar system from the Sun—in good harmony with the value derived by Oort chiefly from B- and *c*-stars. The distribution in the sky and the apparent magnitudes do not favour the view that the long-period Cepheids (periods longer than 10 days) form a natural sequence with the typical Cepheids (compare Araki's dissection on p. 369 of this note). There are indications that their absolute brightness is not very great. It is concluded that the Cepheid type of variability is probably not restricted to stars of high mass or high luminosity, and that a close examination of the spectral type and shape of the light-curve, as well as of the period, is necessary

in determining absolute magnitudes of these stars for the estimation of distances of star groups.

Another statistical investigation is reported by J. Hellerich (*V.J.S.*, *A.N.*, 1928, p. 266), who explores the possibility of relations between the amplitudes of the light and velocity curves of Cepheids. The results show that the amplitudes increase together, and that the smaller the amplitude of the light-curve, the smaller is the variation of spectral type. There is also a close relation between the amplitude and the form of the light and velocity curves; the greater the former, the more unsymmetrical are the curves. The relation is shown more clearly when bolometric brightness is considered; the amplitudes of the light and velocity curves then have an almost linear relation which is followed also by the cluster-type variable RR Lyræ. The relation between form of light-curve and amplitude is established also from other observations. It holds for stars with periods greater than one day as well as for the short-period variables and those in the clusters M3, M72, and ω Centauri—a fact which tells against the hypothesis that stars of long and short period belong to different classes with different origins of light variation, and is favourable to the hypothesis of a common character for the galactic and cluster Cepheids. The absolute brightness is uniquely related to the period, but the amplitude is not. It is suggested that differences of amplitude denote different stages in the development of Cepheids.

E. Hertzsprung reports in *B.A.N.*, 146, that the correlation he has previously found between the light-curves and periods of Cepheids is well supported by his recent observations at Harvard, of which he gives an account.

A study of the light-curves of 14 variable stars having periods between 40 and 70 days, with the object of determining the upper limit to the length of period for Cepheids, has been undertaken by B. P. Gerasimovič (*Harv. Bull.*, 857). He finds a limiting value of 45 days, corresponding, according to the period-luminosity and mass-luminosity relations, to photographic absolute magnitude $-3{\cdot}5$ and mass $16\odot$. Semi-regular Cepheids, such as stars of the RV Tauri type (see below), may have longer periods, and there are one or two instances of regular Cepheids with periods beyond the limit (*e.g.* CG Sagittarii, with a period of 64·1 days).

Long-Period and Semi-Regular Variables.—A considerable amount of attention has been given to stars of the RV Tauri type, or "semi-regular" variables—stars showing light-curves resembling the β-Lyræ type, but much less regular, and with periods between those of Cepheids and long-period variables. V Vulpeculæ, a star showing these characteristics, is discussed by B. P. Gerasimovič in *Harv. Circ.*, 321. The brightness at maximum seems to be invariable at about $8^{m}{\cdot}4$, but the minima vary from $9^{m}{\cdot}0$ to $10^{m}{\cdot}2$. The period is far from constant, and appears to have undergone a sudden change from 74·94 to 75·68 days. Such changes have been previously observed in other stars of this type. The change in this star signifies a transition to a state

of increased stability ; before the change the period showed fluctuations with a period of 12–13 years, but after, the period remained constant and the minima were more regular in depth. The break in the period was not accompanied by a change in median brightness. If explained in terms of a pulsation theory it signifies a sudden expansion of a vibrating star, the equilibrium radius being changed by only $\frac{3}{10}$ of 1 per cent. of its initial value. If the expansion is the result of an increased heat content, V Vulpeculæ furnishes an example of thermal stability.

Z Ursæ Majoris (*Harv. Bull.*, 856) and R Scuti (*Harv. Circs.*, 323, 333), other interesting stars of this type, are discussed by the same writer, and light-curves of R Scuti are given by P. M. Ryves in *M.N.*, **88**, 483. R. Müller (*A.N.*, 5592) suggests that RU Vulpeculæ also is an RV Tauri star.

These stars are interesting as forming a possible link between Cepheids and long-period variables. In *Harv. Bull.*, 861, H. Shapley discusses the possibility of extending the period-luminosity relation for Cepheids to long-period variables, with RV Tauri variables as intermediaries. The principal differences between these types of stars are concerned with the distribution in the sky and the range of variation ; and reasons are given for thinking that these differences are more apparent than real. It is found that the period-luminosity relation is not strictly applicable to the long-period variables, although the fundamental relation between period and density appears to hold approximately in the mean for these stars. It is concluded that the pulsation hypothesis can be logically extended to long-period variation on the basis of the observed similarity to Cepheids in bolometric absolute magnitude, radiation variations, spectral peculiarities, and galactic distribution. The dissimilarities, which are only those natural to the different evolutionary stages of the two groups, affect the mean density, the average spectrum, the visual absolute magnitude, and the mean distance for a given apparent magnitude.

The view that Cepheids and long-period variables are of similar nature is supported also by P. M. Ryves (*Journ. B.A.A.*, **38**, 307), in a discussion of the origin of stellar variation.

A period-luminosity relation for long-period variables is found also by B. P. Gerasimovič (*Proc. Nat. Acad. Sci.*, **14**, 963), who determines the mean absolute visual magnitudes ($\bar{M}$) of these stars at maximum from all available proper motion and radial velocity data. He finds a dependence on period of the following character :—

Period (in Days).	$\bar{M}$.
100–250	−2·3
250–340	−1·1
> 340	+0·3

This period-luminosity relation is not necessarily a direct continuation of Shapley's law for Cepheids, because the changes in absolute visual magnitude are probably chiefly the result of redistribution of light by the absorption bands.

No such relation, however, is found by H. Shapley (*Proc. Nat. Acad. Sci.*, **14**, 958) in a discussion of the long-period variables in the region of the galactic centre (Milky Way field, 185). Regarding the distances of the cluster-type and long-period variables in this field as equal, the absolute magnitudes of the former, derived from the period-luminosity relation, indicate that the long-period variables (which form one-third of the variable stars in the region), which are grouped about apparent photographic magnitude 14·8 at maximum, have the corresponding mean absolute photographic magnitude, − 1·0, and a mean absolute visual magnitude at maximum of not fainter than − 2·5. The long-period variables in this field are uniformly brighter than the cluster-type variables. They seem to fall into two classes with respect to length of period, stars with periods between 250 and 300 days being relatively scarce. This, if it is real, is distinctly different from the distribution of period for these stars in the sky at large (see next paragraph). The dispersion in apparent magnitude is moderate, which is an indication that these stars will be extremely serviceable in the measurement of galactic dimensions.

An analysis of more extensive data, derived at Harvard for nearly 1100 long-period variables of known period, is described by L. Campbell and A. J. Cannon in *Harv. Bull.*, 862. The object of the inquiry was to determine what relations might exist between period, spectrum, range, and brightness. A relation between period and spectrum at maximum for Me stars is the most conspicuous feature of the records, the period increasing with advancing spectral type. A period of about 300 days is most frequent for variables of known spectrum, but for all the stars of known elements taken together, the maximum frequency occurs around 280 days. There is a slight correlation between period and range of variation, the range increasing with length of period and also with advancing spectral type. When all the variables of known elements are considered, it appears that the apparently fainter stars have, in the mean, slightly shorter periods, but if the examination is confined to the stars with observed spectra, no correlation between period and apparent magnitude is evident. This might indicate that there is no relation between period and absolute visual brightness for stars brighter than the 10th magnitude, but that among the fainter stars, brightness increases with period. The investigation suggests that quantitative discussion of the correlations might provide a basis for a physical interpretation of long-period variation.

A strong correlation between the number of faint Mira stars and the galactic longitude is reported by C. Hoffmeister (*A.N.*, 5595) in announcing the discovery of 132 new variables. Preliminary results show that whereas in the Orion and Canis Major fields, 7 per cent. of a total of 46 variables are of Mira type, in the Lyra-Cygnus and Ophiuchus fields there are 45 per cent. of a total of 135. The proportion of Mira stars found is probably in each case too high because of the smaller chance of discovery of variables of other types, especially eclipsing variables, but the relative percentages are held to be of the right order.

Irregularities in the elements of long-period variables form the subject of two papers. In *A.N.*, 5544, R. Müller, referring to Ludendorff's statement that the variations of maximum brightness of these stars are greater than the variations of minimum, shows that the variations depend on the form of the light-curve. Taking Ludendorff's classification (see *M.N.*, **87**, 331, 1927) he finds that this statement is true for stars of class α, the mean error of maximum brightness being almost double that of minimum. For β stars the mean error of minimum is somewhat greater, while the γ stars behave rather irregularly.

Periodic inequalities in the elements of long-period variables are considered by T. Araki in *Jap. Journ. Ast. and Geophys.*, **6**, No. 1, p. 31. He shows that the number of such stars which are known to exhibit these inequalities depends on the year of discovery: of the 84 discovered before 1870, 67·9 per cent. have been found to show the phenomenon, while of the 255 discovered since 1901, only 2·8 per cent. are known to show it. He concludes that the inequality of the elements, whether the variation of light is simply periodic or is subject to a more complex law, is one of the most general properties of these stars.

Certain previously unknown bands in the spectrum of Mira at maximum have been identified by F. E. Baxandall (*M.N.*, **88**, 679) with emission bands of aluminium oxide.

The question whether the recently discovered penetrating cosmic radiation may originate in Mira-type variables, which was previously discussed by A. Corlin and B. P. Gerasimovič (see last year's Council Note), has received further attention during the year. In *A.N.*, 5549, Gerasimovič replies to Corlin's criticism of his investigation, and puts forward evidence that the data considered by Corlin are too uncertain to permit of definitive conclusions as to the correlation of the intensity of the radiation with the positions and magnitudes of the Mira-type variables. Corlin contends in *A.N.*, 5589, that Gerasimovič's reply is very unsatisfactory, and that his method of criticism is open to strong objections, some of which are stated. Corlin considers in some detail Gerasimovič's method of approaching the problem in order to show its inappropriate character and the untrustworthy nature of the inferences which Gerasimovič draws.

An independent investigation of the problem is described by V. Oberguggenburger in *A.N.*, 5550. He compares the curve of daily variation of the cosmic radiation given by Kolhörster and v. Salis for 1926 September 9–15 with the curve of daily variation of the total magnitude of all the Mira variables situated, during the same period, on a celestial circle of 50° radius centred at the zenith of the Jochtrichter. The results show an agreement in the positions of maxima and minima of the two curves during the first 13 sidereal hours, but a discordance during the remainder of the day. The author asks whether the agreement found by Corlin might not be accidental, and regards the data for the Mira stars as not yet sufficiently definite to give a finally established relation. Other groups of heavenly bodies are investigated in a similar way, but with no positive result.

Corlin deals at some length with Oberguggenburger's investigation (*A.N.*, 5566). He agrees that the correlation suggested by himself is not finally established, and states that the results merely give an indication where the source of the cosmic rays might be looked for. His former paper did not put forward a theory that the Mira stars were the origin of the radiation, but raised the question whether the relatively good agreement between the two curves was accidental or corresponded to a physical reality. He proceeds to give further reasons why he considers the latter alternative the more probable. After showing how the discrepancy between his curve for the Mira stars and that of Oberguggenburger arises (through disagreement of the adopted magnitudes of the stars), he states certain principles according to which the data should be chosen, and shows that these lead to an agreement between the Mira star and cosmic curves at least from 0 to 18 hours sidereal time. He then gives reasons for regarding the agreement as not due to chance. In the first place, he considers the sidereal daily periodic variation of the rays as established. Millikan's denial of this is not valid, since he has merely shown that there is no appreciable difference between the mean value of the radiation when the Milky Way is above the horizon and when it is below. But if there is a maximum of radiation not only from the Milky Way but also from a region outside it, this investigation leads to no conclusion. If the existence of a sidereal time variation of the radiation is established (on this point see *Nature*, **121**, 322), then it follows that there must be definite regions of the heavens from which the rays proceed. Speculations on the basis of physical theories are interesting and valuable, but are open to objection because they depend on optical principles which may not be capable of legitimate extension to the penetrating rays. The method of curve comparisons adopted by Oberguggenburger and himself is likewise incapable of giving final results, but it might possibly indicate the region of origin of the rays. The significant part of the curve is not the maximum corresponding to the radiation from the Milky Way, which contains all kinds of cosmic bodies except the spiral nebulæ, but the principal maxima and minima which do not correspond to culmination of the Milky Way—particularly the strong maximum at 13–17 hours sidereal time. Only the Mira stars show a curve resembling the cosmic ray curve in these features. The existence of a strong extra-galactic maximum implies that the rays—or at least part of them—come either from the relatively near parts of the star system or else from a cosmic cloud in the direction 13–17 hours sidereal time which has not yet been observed. If the first alternative be the true one, we are led to the Mira stars as the only source for which there is present evidence. The further question arises whether the hardness of the rays depends on the direction from which they come. Present evidence indicates that the periodic variation characterises mainly the softer rays.

A catalogue of 1760 long-period variable stars is given in *Harv. Ann.*, **79**, part 3.

Irregular Variables.—In *Harv. Bull.*, 857, B. P. Gerasimovič gives

an account of UU Herculis, a variable of a new type. It has two periods (of 72·6 and 45·4 days respectively) which interchange without superposition, as if one definite wave gave place to another. It seems certain that the two waves do not represent independent series of physical events, but are manifestations of one complicated variation. The star has nothing in common with the RV Tauri or U Geminorum type of variable.

Another star of somewhat similar character, Z Cancri, is described by the same writer in *Harv. Bull.*, 862. Its spectral type is M5, and it has three different periods, respectively near to 80, 114, and 166 days, which are intermingled in a much more complicated manner than the two periods of UU Herculis. The range of variation is small, and not at all constant. Stars of this type may represent an intermediate stage between semi-regular and irregular variables. It is suggested that they should be regarded as possessing "cycles" rather than "periods" of variation, a cycle being distinguished from a period by the fact that its recurrences, although they exhibit the same sequence of phenomena, are not equal in duration. A form of "cycle diagram" is described in which each cycle is represented by a dot, the abscissæ denoting cycle durations and the ordinates successive occurrences of the cycle. The characteristics of these diagrams for different types of variable are pointed out.

In *M.N.*, **88**, 660, H. S. Jones reports radial velocity observations of α Orionis and discusses them in relation to the light-curve. He finds that the velocity and light curves are correlated in a manner similar to the relations for Cepheids. A correlation between the radial velocity changes and the changes in diameter is suspected, but cannot yet be considered as established. There should also be related colour changes, but little or nothing is known of them. The paper describes a similar investigation of α Scorpii also.

General.—The practice of periodogram analysis, particularly as applied to the study of variable stars, is discussed by J. van der Bilt in *B.A.N.*, 145; and in *Journ. B.A.A.*, **38**, 71, P. M. Ryves comments on the use of certain pieces of apparatus proposed by W. M. Lindley for variable-star observers.

In *A.N.*, 5569, M. Güssow reports photo-electric observations of variable stars, including β Cephei, which has the smallest amplitude yet observed, viz. $0^{m}\cdot037$.

Pub. Washburn Obs., XV., parts 1 and 2, consist of a valuable detailed account of the photo-electric photometry of stars carried out at the observatory during the years 1916–1926. The programme included the observation of spectroscopic binaries for variations in light, and it has been found that the stars of this class of early spectral type are a specially fertile field for the discovery of new variables—mainly of the eclipsing type. Part 1, by J. Stebbins, describes the methods of observation, the programme, and the results, with a particular account of the eclipsing variables, δ Libræ and α Coronæ, the ellipsoidal variable, ζ Andromedæ, and the irregular variable, 12 Lacertæ. In part 2,

C. M. Huffer similarly discusses the eclipsing variables, 21 Cassiopeiæ and 9 Andromedæ, and the Cepheids, T Vulpeculæ and H. R. 8084. The publication is reviewed by T. S. Jacobsen in *P.A.S.P.*, **40**, 193.

W. H. Christie (*Pub. Dom. Obs. Vict.*, 4, No. 5) also reports an investigation of the velocity and light-curve of 12 Lacertæ, and suggests that the assumption that the star is in process of fission will fit the observations. H. D.

Solar Activity in 1928.

Sun-spots.—The year was one of considerable sun-spot activity, the mean daily area of spots showing a small increase on that for 1927. From provisional measures of areas for 1928 it seems that the maximum of the cycle is spread over the three years 1926–28, with peaks in 1926 and 1928. The average daily number of spots, on the other hand, appears to have reached a maximum during 1928. The average latitude (14°) of spots for 1928 also indicates that the maximum has been reached. There were a number of large groups, for which the time of centre meridian passage and latitude are tabulated below. Each of these groups, except No. 10, exceeded 1000 millionths of the Sun's hemisphere for several days, and were, in consequence, seen fairly easily with the naked eye.

(1)	Jan. 22·8	15° N.	(7)	Sept. 12·7	15° N.
(2)	Feb. 21·6	6° N.	(8)	,, 24·4	15° N.
(3)	May 8·4	14° S.	(9)	,, 27·4	15° S.
(4)	July 12·4	8° N.	(10)	Nov. 9·4	16° S.
(5)	,, 17·5	18° S.	(11)	Dec. 5·6	9° N.
(6)	,, 31·8	14° N.			

No. 3 was an exceptionally long, straight stream. No. 4 was an active group, showing in its spectrum bright reversals of the infra-red lines of ionised calcium, λλ 8498, 8542, and 8662 (*Publications of the Astronomical Society of the Pacific*, 1928 October, p. 348, and *The Observatory*, 1928 November, p. 349). No. 9 was the largest group seen for two years; it grew with great rapidity to a complicated stream. No. 3, Nos. 8 and 9, and No. 11 were within four days of the Sun's central meridian at the time of commencement of considerable magnetic disturbance (range in $D \geqq 30'$ or in $H \geqq 150\gamma$). The largest magnetic storm of the year, on July 7-8, occurred, however, with no unusual spot within four days of the central meridian, group No. 4 being over 55° east of the central meridian at the time of commencement.

H. W. N.

The Prominences.—The mean daily areas in square minutes of arc derived from the Kodaikánal photographic records are as follows :—

	North.	South.	Total.
1928 January to June . . .	3·80	3·50	7·30
July to December . . .	3·66	3·47	7·13

The mean daily numbers were 19·6 and 18·4 for the first and second half-years respectively. Compared with the year 1927, areas show an increase of 8 per cent. and numbers a slight decrease.

A minimum of prominence areas near 50° is common to both hemispheres. There are peaks near 30° and 70° in the northern hemisphere, and at 15°, 35°, and 60° in the southern. The activity near the poles is practically confined to the northern hemisphere.

A prominence reaching to a height of 20′·9, or 910,000 km. above the chromosphere, was photographed on 1928 November 19.

Prominences exhibiting metallic lines numbered 79 as against 81 in the year 1927. None of these were in high latitudes, and only two between 31° and 40° in the first half of the year; all the rest were below 30°. Displacements of the hydrogen line in the chromosphere and prominences observed during the year numbered 1061 as against 787 in 1927. Of the displacements, 593 were towards the red, 449 towards the violet, and 19 both ways simultaneously. Bright reversals of the Hα line in the neighbourhood of sun-spots numbered 915, as against 803 in 1927. Displacements of the Hα line on the disc totalled 352, an increase of 14 per cent. over those of the previous year. Of these displacements, 252 were towards the red, 96 towards the violet, and 4 both ways simultaneously. D_3 was observed as a dark line on 841 occasions, as against 643 during 1927.

The mean daily area of prominences projected on the disc as absorption markings in hydrogen light was 4088 millionths of the sun's visible disc, an increase of 8 per cent. on the previous year. Of these, 64 per cent. occurred in the southern hemisphere, an unusually large predominance, especially in view of the fact that prominences at the limb show a slight predominance in the northern hemisphere. The distribution in latitude is similar to that of prominences at the limb, except that north of 50° the activity is very small.

T. R.

Solar Research in 1928.

Revised Rowland Wave-lengths.—One of the most important contributions to the tool-chest of the worker on solar research has been supplied by the Carnegie Institute of Washington (Publ. 396) in the "Revision of Rowland's Preliminary Tables of Solar Spectrum Wave-lengths with Extension to the Infra-red, to 10218·6A," carried out by C. E. St. John and a band of colleagues. This work has been long needed, but it has luckily come at a date when in addition to revised wave-lengths on the I.A.U. scale, it is possible to publish for many lines data as to their physical classifications. All strong lines save one at λ6155 have now been identified, 57 elements have been found present, and 32 of these show enhanced lines in the Fraunhofer spectrum; no lines from doubly ionized atoms are definitely identified. A calibration of Rowland's scale of intensities of solar lines has been made by Russell, Adams, and Moore (*Ap. J.*, **68**, 1), and multiplets have been used to deduce the relative numbers of active atoms of different elements

in various stages of excitation. A. S. Fairley has calculated from a study of the D absorption lines in *Na* vapour (*Ap. J.*, **67**, 114) that a column of 4×10^{13} *Na* atoms per sq. cm. of the solar atmosphere is required to produce the D lines observed in the Sun's spectrum.

Spectral Lines.—Lines continue to be identified in solar spectra, though not always previously recognised in the laboratory—*e.g.* lines of *Cr*II (Dunham and C. E. Moore, *Ap. J.*, **68**, 51) and of *Fe*I (C. E. Moore and Russell, *Ap. J.*, **68**, 151). Low level and enhanced lines of the rare earths have been detected by St. John and C. E. Moore (*Ap. J.*, **68**, 93), the ten elements *La*, *Ce*, *Pr*. *Nd*, *Sa*, *Eu*, *Gd*, *Dy*, *Er*, and *Sb* all being found ionized. S. B. Nicholson and Perrakis have called attention (*C.R.*, **186**, 492) to the absence from the solar spectrum of evidence for elements of high ionization potential (except *He*), and the presence of elements of low ionization potential except *B*, whose strong lines are too far in the ultra-violet to be observed. The same two authors (*ibid.*, 1523) report later the discovery of *B* molecules in sun-spots, while Deslandres (*ibid.*, 495) suggests that ionized *He* arrives at high levels in the sun, shot up as radio-active particles from some disturbed levels below. Piccardi (*Nature*, **122**, 880) suggests the presence of secondary hydrogen in sun-spot spectra.

H. von Klüber (*A.N.*, **231**, 417), in a discussion of the contours of the solar absorption lines, verifies for Hα and K a formula for the intensity $\propto e^{(\lambda-\lambda_0)^2}$, and draws attention to the presence in sun-spot spectra of the forbidden *Ca* line at 6156·31A as a weak line. Bowen and Menzel (*P.A.S.P.*, **40**, 332) have tabulated likely forbidden lines of different elements; they have failed to get identifications in stars of Bep-type or in the corona, but suggest a forbidden *Fe*II multiplet $a^6\mathrm{D} - a^6\mathrm{S}$, and one or two others as present in the flash spectrum.

Chromosphere.—Milne's theory of the calcium chromosphere supported by selective radiation pressure comes in for a good deal of discussion. W. Anderson (*Zeits. f. Physik.*, **49**, 749) shows that Gurney's explanation (*M.N.*, **88**, 377) of *He*I lines extending to much higher levels than *He*II lines as due to ionization by collision with falling atoms of doubly-ionized *Ca* agrees numerically with the heights of the different elements found in the 1926 eclipse by Davidson and Stratton. Anderson (*Z. f. Physik.*, **46**, 445) criticises Milne's theory as giving too high a value for the ratio Ca^{++}/Ca^{+} at the upper limits of the chromosphere. He also criticises Unsöld's theory as giving too high densities. Milne also criticises as impossible the high pressures at the base of the chromosphere required by Unsöld's theory, based on the residual intensities at the centres of the absorption lines as measured by von Klüber. This controversy is being conducted in a series of papers in the *Z. f. Physik.*, **46**, and the *M.N.*

A good account of the results to be deduced from Minnaert's work on the contours of the absorption lines in the Sun's spectrum, and the agreement of Minnaert's results with Lindblad's and Milne's theories on the darkening of the limb is given by the last named in *The Obser-*

vatory (**57**, 88); here there is also given an account of the reconciliation between the lower effective temperature found from Stefan's Law and the solar constant and the higher temperature found from Planck's Law and the shape of the solar energy curve. Unsöld applying his theory of a chromosphere in thermodynamical equilibrium to the limb spectra of the Sun finds confirmation in the presence of bright emission on both sides of the central absorption line at Hα. The self-reversed strong lines found at the limb are also claimed by Unsöld as being in accordance with his theory.

Woltjer criticises Milne's theory (*B.A.N.*, **4**, 259) from the provisional estimate made by Davidson and Stratton of the intensity of the Ca^+ light from a high prominence compared with the light of the neighbouring continuous spectrum; but Pannekoek (*ibid.*, 263) answers this by a reference to the narrowness of the bright chromospheric lines. The difficult problem of the intensity and self-absorption of the chromospheric lines is also discussed by Pannekoek, and related to the absorption produced by atoms of the chromosphere in the Sun's spectrum. The results given by Davidson, Minnaert, Ornstein, and Stratton (*M.N.*, **88**, 534) who find reasonable agreement between the observed and the theoretical relative intensities of lines of a multiplet, differ from those of Pannekoek and Minnaert (*Verh. d. k. Akad. v. Wetens te Amsterdam*, **13**, No. 5) who find no such agreement. The explanation of this difference must lie in part in the very different solar levels involved in the two sets of data—a high prominence was examined in the former paper and a low chromosphere photographed actually before totality in the latter paper. The rapid fading of Hγ with height found by Pannekoek and Minnaert is inconsistent with other observations, and has yet to be explained.

Milne's work is connected up to Schwarzschild's earlier work by Hopf (*Z. f. Phys.*, **46**, 374), who takes the Sun's curvature into account, and by McCrea (*M.N.*, **88**, 729) in a criticism of P. A. Taylor's paper on "The Equilibrium of the Calcium Chromosphere." McCrea also discusses (*Camb. Phil. Soc. Proc.*, **24**, 506) the line intensities of hydrogen in the chromosphere, but finds it impossible to distinguish between thermodynamical and radiative equilibrium.

L. d'Azambuja publishes (*C.R.*, **187**, 201) an account of a spectroheliogram secured with the slit at the centre of the *Ca*II line at 8542A. Faculæ and filaments were well seen and the spectroheliogram resembled that of K_3; he also describes the nature of the *Cartes Synoptiques* which the Observatory of Paris is publishing for a number of years with the aid of the I.A.U. (*Ann. de l'Obs. de Paris-Meudon*, **6**, Fasc. 1, 2, 3). Perepelkin (*Z. f. Physik.*, **49**, 295), comparing high prominences with the chromosphere, finds that the ratio of intensity of Hα to D_3 decreases with height; in the greater optical depth of the chromosphere, self-reversal is more quickly apparent for D_3 than for Hα. Pike has discussed (*M.N.*, **88**, 635) the separation of different gases in prominences required by his theory of motions under radiation-pressure. Evidence is not yet available to decide the points raised.

Corona.—A difference of distribution of continuous radiation with height is indicated for the corona in the British eclipse spectra secured in Sumatra in 1926. The slope of the intensity curve over a small region of the spectrum of the low corona—or of a high prominence—indicates a low temperature increasing with height. Probably at the higher levels there is a larger proportion of reflected sunlight (*M.N.*, **88**, 544). An identification of the unknown lines of the spectrum of the corona with a group of argon lines is suggested by J. M. Freeman (*Ap. J.*, **68**, 177). A crucial test of this view will be a determination of the single or double nature of the green coronal line. Vegard (*Norske. Vid. Akad. Oslo. Mat. Nat. Kl.*, 1928, No. 2) gives wavelengths of the coronal spectrum, obtained with a quartz spectrograph at Ringebu in 1927, between 3200A and 3900A, and also between H and Hα.

A somewhat complex law for the distribution of the brightness in the corona is given by Balanovsky and Perepelkin (*M.N.*, **88**, 740) from a study of the isophotes of the corona, as photographed by them at Malinberget in Sweden in 1927. Ludendorff in a careful study of published photographs of the corona (*Sitz. d. Preuss. Akad. d. Wiss., Phys. Math. Kl.*, 1928, xvi.) finds that the shape of the corona depends upon the actual spottedness of the Sun near the limb at the time of the eclipse rather than upon the phase of the sun-spot cycle. He also shows that the ellipticity of isophotes of the corona increases with the distance from the limb especially at minimum. Horn d'Arturo (*Publ. del. Oss. Ast. de Bologna*, **1**, No. 10) defends his previous contention about marked changes in the corona in a few hours' interval in 1926, as shown by the coronal pictures in Africa and Sumatra, by showing that the variations observed are in both senses—appearance and disappearance—and that these cannot be both due to differences in the emulsion or development of the plates. The hopes that we might be able to check a number of doubtful points about the corona by photographing it outside a total eclipse were renewed by Blunck's experiments (*A.N.*, **231**, 357), but these results were not confirmed by Kienle (*Veroff. d. Univ. Sternwarte zu Göttingen*, Heft 4); he has pointed out from a consideration of the laws of scattering of light, of the known relative brightness of the Sun and the corona, and of their similar distribution of continuous radiation, that no success is to be hoped for by any method of direct photography. He suggests, however, from Davidson's experiments at Greenwich that the flash spectrum can be photographed outside eclipse times, and that with a suitably designed spectrograph, used under good seeing conditions, spectrophotometric work might be attempted. Further, he adds that stars might be photographed near enough to the Sun to test the Einstein problem, but that good enough images could not be expected for useful or decisive results.

The structure of the corona as observed at Benkoelen in 1926 with very different exposures and with instruments of different focal lengths is discussed by Miller and Marriott (*P.A.S.P.*, **40**, 83). A coronal spike was measured up to 6 solar radii from the centre of

the Sun. Fraunhofer lines in the continuous spectrum of the outer corona indicated an outward flow of 16 km./sec. ± 12 km./sec. Direct colour photography of the corona was carried out by W. M. Powell. Photographs of the corona secured in 1927 at Gëllivare in N. Sweden and at Enontekiö in Finland have been published respectively by Öpik (*Pub. de l'Obs. Astron. de l'Univ. de Tartu* (*Dorpat*), **26**, No. 6) and by the members of the astronomical section of the Russian Society, Mirovédénïé, Leningrad (*Pub.*, No. 6). In the case of the former expedition the photometric results were spoilt by haze.

Eclipses.—An important paper on the methods and problems of eclipse spectrophotometry has been published by Pannekoek and Minnaert (*Verh. d. k. Akad. v. Wetens te Amsterdam*, **13**, No. 5). Details as to some of the interesting results have been given above.

Gravitational Displacement of Spectral Lines.—St. John (*Ap. J.*, **67**, 195) obtains confirmation of the Einstein shift from a study of 1537 lines at the centre of the Sun's disc and 133 lines at the edge compared with a vacuum source. The problem is complicated by the presence of low-level upward currents in the Sun and the general solar circulation, but after a careful study of these extraneous disturbing factors St. John finds good evidence for the slowing down of the atomic clock to the full extent required by the theory.

Solar Radiation.—Pyrheliometric measures of solar radiation, made at Tacubaya 1911–15, have been reduced and discussed in *Bol. del. Obs. Nat. de Tacubaya*, No. 10. The month of minimum radiation or least atmospheric transparency is April, the last dry month before the wet season. I. Yamamoto, studying from material collected at Mt. Wilson the inter-relation of solar activity and variations in the solar constant (*Mem. of Coll. of Science Kyoto Imperial Univ.*, **11**, 233), confirms Abbot's results that the solar constant rises with new or increasing spots and with activity in Hα faculæ, and falls with central spots or prolonged periods of quiescence. Parchomenko (*A.N.*, **233**, 329) also claims agreement with Abbot's observations and variations in the upper layers of the solar atmosphere, and da Costa Lobo (*Coïmbra Spectroheliographic Results*, 1926–27) puts forward the same general idea that condensations in the facular regions affect the outward flow of effects arising from internal disturbances in the Sun. Stebbins and Jacobsen (*L.O.B.*, 401), from photometric measures of Uranus and of Jupiter's satellites on 47 nights, fail to detect any change in the solar radiation—the average deviation for a night being ± $0^{m}.006$ for the satellites and ± $0^{m}.0036$ for Uranus.

Kienle and Juška (*Z. f. Phys.*, **47**, 426) have made a fresh investigation of the distribution of brightness over the Sun's disc to within 1 per cent. of the radius from the limb. Their conclusions as to the more gradual falling off of the light are contested by Minnaert (*M.N.*, **89**, 197), who bases his support of the older view of the sudden falling off of intensity at the limb on the observations of Julius and Moll at

the almost total eclipse of 1912, and on Schwarzschild's observations in 1905, and Stetson's in 1926.

Sun-spots.—Two conflicting explanations of the periodicity of sun-spots have been put forward by Göschl (*A.N.*, **232**, 203) and Oppenheim (*A.N.*, **232**, 369). The former attributes it to inflowing meteors, and associates the periodicity with conjunctions of planets at points having a special relation to the direction of the Sun's motion ; the latter, using Kimura's periods, shows that the spottedness can be expressed in a set of terms of the form

$$A \cos (\phi t + e\mu_m \cos (m\phi t - \xi_m)),$$

suggesting a linear differential equation whose coefficients are periodic functions of t, which in turn suggests periodic internal disturbances as the underlying cause. An interesting addition to the list of secondary phenomena which have in the past been correlated with the sun-spot cycle is suggested by De Lury (*Pop. Ast.*, **36**, 231)—the number of pelts of rabbits collected by the Hudson Bay Company varies with the sun-spot period.

The temperature within sun-spots at different optical depths has been examined by Ambarzuniam and Kosirev (*A.N.*, **233**, 107) by photometry of the continuous spectrum. They estimate the depth of a spot as not more than 100 km. R. S. Richardson (*P.A.S.P.*, **40**, 343, 348) gives an account of an individual active spot with curiously distorted lines and of another spot for which the Ca^+ triplet in the infra-red showed both bright and dark components.

Magnetic Fields.—Richardson also draws attention (*ibid.*, 126) to the magnetic storm on the earth on 1928 January 26, which started between 10^h and 31^h after the formation of a bright hydrogen eruption observed at Mt. Wilson. Greaves and Newton (*M.N.*, **88**, 556, and **89**, 84) state that fifty-four years' records show that the coincidences of large spots and storms are more frequent than chance would explain, and that the large spots which seem to be involved are more frequently near the centre than the limb, but they admit that magnetic storms do occur in spotless periods.

Yamamoto (*Mem. Coll. Sci. Kyoto Imperial Univ.*, **11**, 303) finds that the field intensity of bipolar spots increases with the distance between each pair of spots. Chapman has shown (*M.N.*, **89**, 57, 80) that the narrow radial limitation of the Sun's magnetic field may be explained by an eastward drift of electrons, the field falling from 50 to 10 gauss probably in a layer of 25 km. The field cannot extend up to the chromosphere where selective radiation pressure becomes important.

Daily Character Index.—An addition to the regular annual reports on solar activity has been made in the *Bulletin for Character Figures of Solar Phenomena*, edited by Brunner of Zürich and published under the auspices of the I.A.U.

Planetary Spectra.—McLennan has investigated the absorption bands in the spectra of the major planets, and suggests (*Proc. R.S.*, **120**, 296) that the bands in the red, common to the four giant planets, may be traced to water in the liquid state, or possibly to water-vapour at very low temperatures. F. J. M. S.

Stellar Spectroscopy in 1928.

Ionization.—Milne has obtained (*M.N.*, **89**, 17, 157) a generalized Saha formula and discussed the connection between the coefficient of opacity and the temperature of maximum intensity for a spectral line in a sequence of stars with the same g. He derives a method of measuring the coefficient of absorption for stellar atmospheres, and explains the observed fact that lines of the neutral as well as the ionized atom strengthen in passage from dwarfs to giants. Considerable observational work is required to test these theories.

Classification.—Adams and Russell have published (*Ap. J.*, **68**, 9) some preliminary results of a new method for the analysis of stellar spectra, connecting the relative numbers of atoms producing lines in different stars with the relative numbers of normal neutral atoms, and correlating temperature, electron pressure, and the state of ionization of the stellar atmosphere. Their preliminary results suggest departure from local thermodynamical equilibrium in stellar atmospheres, the number of atoms in excited states being higher than theory would suggest.

Cannon has analyzed (*H.C.O. Bull.*, 862) the distribution of spectral classes and visual magnitudes of 15347 stars in the Henry Draper Extension and Gesellschaft Catalogues. She has also tabulated (*H.C.O. Ann.*, **100**, No. 4) the magnitudes and spectra of 4200 stars, not in the Draper Catalogue but in the Helsingfors-Gotha Catalogue of the *A.G.* H. H. Plaskett's classification of O-type stars was adopted at the I.A.U. meeting at Leiden, when an extension by Payne (*H.C.O. Bull.*, 855) to nebulæ was also discussed ; this extension is based upon grounds of ionization. From these two writers at Harvard came an alternative suggestion for a new classification scheme based on abundance, ionization, and temperature as indicated in several ways.

Shane has made a photographic study (*Lick O.B.*, 396) of the spectra of classes R and N. The variation in strength of the cyanogen bands and Swan groups has been studied in detail, and some bands of unknown origin have been measured at 4642, 4572, 4540, and at 4976, 4905, 4866. Leon Campbell (*H.C.O. Bull.*, 862) has examined the relations between the range, period, and the spectral classes of long-period variable stars, particularly Me stars.

Spectrophotometry.—Payne has examined the contours of prominent stellar lines (*Proc. N.A.S.*, **14**, 399), analysed them, and compared them with Unsöld's theory. She finds the hydrogen lines flattest when at

maximum strength, sharpening with the series down to M stars, while the *Ca* lines flatten towards the cooler stars. She also has examined (*ibid.*, 296) the distortion of the continuous background by wide absorption lines, and notes that colour indices will be affected in stars with strong, broad, hydrogen lines. Narrow-lined super-giants should give more correct results in temperatures deduced from their continuous spectra than ordinary giants. C. T. Elvey has shown (*Ap. J.*, **68**, 145) that the contours of the hydrogen lines of Sirius and eleven other A-type stars correspond to $I = I_0 e^{-(\lambda-\lambda_0)k}$, von Klüber's formula for resonance absorption. Milne has worked out (*M.N.*, **89**, 3) the theoretical contours of absorption lines in stellar atmospheres, calculating for any point of a line contour the optical depth for which the same intensity-ratio is found as for a set of atoms, transparent save for the one line frequency, placed in front of a surface radiating with photospheric intensity. He obtains, with certain assumptions, 5·5 for the mean mass absorption of the reversing layer.

Payne and Hogg have examined (*H.C.O. Circ.*, 334) the contours of lines of *Ca* and Ca^+ in stars of types A–M. Interpreting their measures in terms of Unsöld's formulæ they have evaluated the numbers of *Ca* atoms in the stellar atmospheres. They find an increase in the number of effective atoms above the photosphere as we pass from Go to M7. Pressures have been derived from the ratios of Ca^+ to *Ca* and values for *g*. Contours of *Ca* lines in late type stars have been measured by Hogg (*H.C.O. Bull.*, 859), and of *H* lines in stars of Class A by Dunham (*H.C.O. Bull.*, 858).

Öhman has studied photometrically (*Medd. f. Ast. Obs. Upsala*, No. 33) the effect of luminosity and colour in short objective prism stellar spectra. He finds close agreement with Lindblad's luminosity diagram, and he notes a correlation between the strength of K (and $H\gamma$) and the colour equivalent of the star.

In studies of special stars we may note the abnormally low temperature for P Cygni (7700° and not 10,000° as was to be expected) found by Gerasimovič, the ratios of the intensities of the emission lines to the absorption companions in the same star (these ratios diminish with shorter wave-lengths for both *H* and *He*; Elvey, *Ap. J.*, **68**, 416); and the abnormally low temperature of ζ Persei found by Kienle (*M.N.*, **88**, 700), and also by Greaves, Davidson, and Martin (*ibid.*, 702). Payne has studied some Ti^+ multiplets in ε Aurigæ (*H.C.O. Bull.*, 855) and compared her measures with the visual intensities of Miss Maury.

Miscellaneous.—Baxandall has identified (*M.N.*, **88**, 679) some bands discovered by Joy in the spectrum of *o* Ceti at a maximum in 1924 February as due to aluminium oxide. Merrill has identified (*Ap. J.*, **67**, 391) emission lines in the spectrum of η Carinæ as arising from metastable states of Fe^+. He postulates very low density as a probable explanation of their appearance. He also notes (*Ap. J.*, **67**, 179) the presence of nebular lines in the spectrum of RY Scuti, with other lines of unknown origin at 4701·5, 4733·6, 4755·0, and 4770. The metastable lines of Fe^+, known in η Carinæ, have been found also by

Adams and Joy (*Pub. A.S.P.*, **40**, 252) in the spectrum of RT Serpentis, which should now be classed among the nova-like variables. Merrill (*Ap. J.*, **67**, 405) finds these lines in HD 45677.

Bowen (*Ap. J.*, **67**, 1) discusses his identification of the nebular lines as due to *N*II, *O*II, and *O*III, and the stage of ionization indicated for other lines by their distribution in the monochromatic images of planetary nebulæ. He also suggests (*P.A.S.P.*, **40**, 336) *C*III as the origin of a forbidden line at 3869. Merrill finds (*Pub. A.S.P.*, **40**, 254) that Wright's nebular line at 7325 is double and corresponds to forbidden lines in *O*II. Lockyer (*M.N.*, **88**, 683) continues his investigation of the changes of spectra found in Bep stars. Belopolsky (*A.N.*, **234**, 93) discusses the changes in intensity of the bright lines in α^2 Canum Venaticorum. Between 1913 and 1928 the period indicated has dropped from $5^d.4705$ to $5^d.4687$. Variation of spectrum, particularly in the bright hydrogen lines, has been noted by Gerasimovič (*H.C.O. Bull.*, 854) in the B2 star μ Centauri.

Kukarin traces a connection between spectral type and period in W Ursæ Majoris stars (*Ver. von Freunden der Physik und Astronomie in Nishni-Novgorod*, "*Veranderliche Sterne*," **1**, No. 7); his formula is spectrum = A3 − 3½ log P, the unit being one-tenth of the interval between two spectral classes. Shapley attributed certain shallow absorption bands found by him (*H.C.O. Circ.*, 317; *H.C.O. Bull.*, 850, 857) in stellar spectra, and confirmed by Lockyer (*M.N.*, **89**, 127), to meteoric cyanogen. Later he traced them to absorption in the lenses and prisms of his optical train.

Moore in a recent study (*Pub. A.S.P.*, **40**, 229) of the companion of Sirius has confirmed the value for the Einstein displacement of the lines found by Adams.

Spectroscopic Parallaxes.—Edwards (*M.N.*, **88**, 695) notes a correction to spectroscopically determined stellar parallaxes; he prefers the assumption that the difference of magnitudes of the components of a spectroscopic binary should be the average value for visual binaries of the same type to the alternative hypothesis which makes one component much brighter than the other.

Binaries.—No fewer than twenty-three papers, one of which gives the orbits of thirteen stars (Jones, *Cape Annals*, **10**, No. 8), have been published on spectroscopic binaries. We must content ourselves with points of special interest. The above paper points out that 42 Capricorni shows a real change between 1917 and 1928 in the velocity of the system. Details of other investigations will be found in the *P.A.S.P.*, *Cont. ast. d. R. Specola di Merate*, *Ap. J.*, *Jour. R.A.S. Canada*, *M.N.*, *Lick O.B.*, *Pub. D.A.O.* Outstanding anomalies in the velocity and light curves of 12 Lacertæ are pointed out by Christie (*Pub. D.A.O.*, **4**, No. 5); a complex multiple system, 13 Ceti, is discussed by Pogo (*Ap. J.*, **68**, 116); a mass of 1000 ⊙ is indicated for 27 Canis Majoris according to O. Struve (*Ap. J.*, **68**, 109).

J. S. Plaskett, comparing the continuous spectrum of *v* Sagittarii

with those of other stars of nearly the same magnitude and zenith distance, shows (*Pub. D.A.O.*, **4**, No. 9) that the Fo or metallic spectrum is the fundamental one. He lists a number of lines of unknown origin in the spectrum.

The hodographic method of Laves for determining the elements of spectroscopic orbits is discussed (*Ap. J.*, **67**, 262) by Pogo.

Radial Velocities.—Three important catalogues of radial velocities were published during the year. Campbell and J. H. Moore (*Lick Obs. Publ.*, **16**) give the radial velocities of 2392 stars brighter than visual magnitude 5·51. Only 49 stars brighter than this limiting magnitude were examined neither at Mt. Hamilton nor in Chile. The solar motion is determined and suggestions made for securing homogeneous results for stars of different spectral types. Spencer Jones (*Cape Annals*, **10**) obtains radial velocities for 434 stars. He deduces the solar apex and details of the ellipsoid which represents the preferential directions of motion of the stars. From 19 specially selected stars observed from 1908 to 1913 Jones deduces $\kappa = 20''{\cdot}478 \pm 0{\cdot}010$ and $\pi = 8''{\cdot}803 \pm 0''{\cdot}004$. Voûte, at Lembang, has published (*Ann. v. d. Bosscha-Sterrenwacht, Lembang*, **3**, 1) a second catalogue of radial velocities combining the results published by sixteen observatories.

Albrecht (*Ap. J.*, **67**, 305) has been examining the systematic differences between the radial velocities given by lines due to *O*II, *N*II, and those obtained from *H*, *He*, *Mg*II, *Si*III. Whether the differences are due to relative motions between the gases or to errors in the comparison wave-lengths is not known.

Irregular short-period fluctuations in radial velocities in α Orionis and α Scorpii are noted by Jones (*M.N.*, **88**, 660), who discusses the possibility of an explanation in terms of pulsation.

Interstellar Calcium.—O. Struve (*H.C.O. Bull.*, 857, and *Ap. J.*, **67**, 353) shows from a study of over 2000 stars that the fixed calcium lines in early type stars are stronger for the fainter stars and for the earlier spectral types. Distance of star, not its luminosity or spectral type, seems to be the important factor. Struve agrees on the whole with Eddington's theory, and H. A. Wilson (*Ap. J.*, **68**, 423) shows that the numerical value for the density of the calcium cloud suggested by Struve's data and laboratory tests agrees well with Eddington's estimate. Pearce (*Pub. D.A.O., Victoria*, **4**, No. 6) finds for HD 176853 a velocity of approach from the stationary K line of 12·6 km./sec., agreeing with nine other stars in the Perseus-Cassiopeia region. The star is abnormally red, $0^{m}{\cdot}75$ fainter photographically than would normally be expected.

Instruments.—Hamy (*C.R.*, **186**, 1392, and *Ap. J.*, **68**, 403) discusses an instrumental device by which a plate containing a very narrow spectrum of a star, mounted on the end of a tuning-fork vibrated by an electromagnet, can be used satisfactorily for Hartmann's method of comparison with a solar or standard spectrogram. Merrill (*Ap. J.*, **68**, 425) describes an application of a telephoto lens to the collimator

of a spectrograph which is very useful for shortening the interval from slit to prisms or grating in the case where the spectrograph is mounted on a telescope. Childs gives (*Proc. Phys. Soc., London*, **40**, 132) an account of his methods of estimating the intensities of spectral lines, with a useful bibliography on the subject.

Laboratory Spectra.—Only the briefest references can be given here to the mass of work done on spectra in the laboratory. Of special interest are some measures by Babcock of the effect of varying pressure (less than one atmosphere) on displacements of lines in the iron arc (*Ap. J.*, **67**, 240): lines arising from high energy states are most affected. The displacements of the lines are to be interpreted as displacements of the energy levels involved. Hanot (*C.R.*, **186**, 1716) discusses the broadening of the hydrogen lines in an electric arc with close electrodes as the current increases. The theoretical intensities of the Balmer lines are discussed by Slack, *Phys. Rev.*, **31**. A great deal of work has been done in classifying the lines of elements in terms of multiplets. The needs of a reader of these notes will probably be met by a list of the elements noted by the writer with a reference to the journal in which the work is published. In all cases it is the volume or volumes for 1928 that are involved.

Element.	Reference.
*A*I and *A*II	*Proc. Physical Soc. London*, **40**; *Zeit. f. Phys.*, **48, 50**; *Phys. Rev.*, **32**; *Proc. K. Akad. Amsterdam*, **31**.
Ag	*Phys. Rev.*, **31**; *Trans. R.S. Canada*, **22**.
Al	*C.R.*, **187**.
Br	*Japanese Journal of Physics*, **5**; *Ann. de Physique*, **9**.
*C*I and *C*II	*Proc. R.S.*, **118, 119**.
*Ca*IV and *Ca*V	*Phys. Rev.*, **31**.
*Cb*III and *Cb*IV	*Phys. Rev.*, **31**.
*Cd*III	*Phys. Rev.*, **31**.
Ce	*Ap. J.*, **68**.
*Cl*II, *Cl*III, *Cl*IV, *Cl*V	*Phys. Rev.*, **31**; *Ann. de Physique*, **9**; *Japanese Journal of Physics*, **5**.
*Co*II	*Zeit. f. Phys.*, **47**.
*Cr*I	*Ap. J.*, **67**.
*Cs*I	*Proc. R.S.*, **120**.
*Cu*II	*Proc. R.S.*, **119**; *Phys. Rev.*, **31**.
*F*I	*Proc. R.S.*, **117**.
*Ge*I, *Ge*II, *Ge*III, *Ge*IV	*Phys. Rev.*, **31**; *Proc. N.A.S. Washington*, **14**; *Proc. R.S.*, **119**; *Zeit. f. Wiss. Phot.*, **25**.
H	*Ap. J.*, **67**; *Phil. Mag.*, **6**; *Zeit. f. Phys.*, **50**.
He	*Zeit. f. Phys.*, **51**.
*Hf*I, *Hf*II, *Hf*III	*J.O.S.A.*, **17**; *Bureau of Standards*, Paper No. 8.
Hg	*C.R.*, **187**; *Phil. Mag.*, **6**; *J.O.S.A.*, **17**.
*In*IV	*Phys. Rev.*, **31**.
*K*III, *K*IV	*Phys. Rev.*, **31**; *Indian Journal Physics*, **3**.
*Kr*II	*Proc. R.S.*, **120**; *Zeit. f. Phys.*, **47, 50**; *Trans. R.S. Canada*, **22**.
N	*Ap. J.*, **68**; *Phil. Mag.*, **6**.
Na	*Phil. Mag.*, **5**.
*Ne*I, *Ne*II, *Ne*III	*Phys. Rev.*, **32**; *Zeit. f. Phys.*, **46, 50**; *Proc. N.A.S.*, **14**; *Proc. Phys. Soc.*, **40**; *Inst. of Physical Research, Tokyo*, Paper 127; *Proc. K. Acad. Amsterdam*, **31**.

Element.	Reference.
*N*iII	*Phys. Rev.*, **31**.
*O*II, *O*III	*Proc. R.S.*, **117**; *Ann. de Physique*, **9**; *Phys. Rev.*, **31**.
*P*III	*Phys. Rev.*, **31**.
*Pb*III	*Proc. N.A.S.*, **14**.
Pr	*Ap. J.*, **68**.
*S*II, *S*III, *S*IV	*C.R.*, **186, 187**; *Phys. Rev.*, **32**.
*Sb*I, *Sb*IV	*Proc. Camb. Phil. Soc.*, **24**; *Proc. N.A.S.*, **14**.
*Se*II, *Se*III	*C.R.*, **187**; *Bull. Acad. Polonaise Sci.*, **3***a*.
*Si*II, *Si*III, *Si*IV	*Phys. Rev.*, **31**.
*Sn*V	*Proc. N.A.S.*, **14**.
*Te*II, *Te*III, *Te*IV	*C.R.*, **187**.
*Th*II	*Proc. N.A.S.*, **14**; *Journal de Physique*, **9**.
Xe	*Proc. Phys. Soc.*, **40**; *Zeit. f. Phys.*, **47**; *Trans. R.S. Canada*, **22**.

F. J. M. S.

Nebulæ.

The present note deals with the three years which have elapsed since the last Council Note on Nebulæ.

General Classification of Nebulæ.—The necessity of a general classification of nebulæ which adequately represents present knowledge, based on the large amount of photographic material now available has been evident for some time. A classification was suggested by Hubble for consideration at the Cambridge Meeting of the I.A.U. in 1925, and this has been published by him in *Mt. Wilson Cont.* 324.* A broad division between the nebulæ associated with the galaxy and those now known to be entirely independent of it can be made without question, under the description of "galactic" and "extragalactic" objects. The galactic nebulæ fall naturally into two groups—the Planetaries and the Diffuse. Hubble divides the latter again into

(1) Predominantly luminous.
(2) Predominantly obscure.
(3) Conspicuously mixed.

The classification of the extragalactic nebulæ is not so simple. Hubble divides them into Regular and Irregular.

The Regular are again divided into two groups—Elliptical and Spiral, the latter being subdivided into

(*a*) Normal Spirals.
(1) Early. (2) Intermediate. (3) Late.
(*b*) Barred Spirals.
(1) Early. (2) Intermediate. (3) Late.

A criticism of this classification of the spirals was made by Reynolds in *The Observatory*, 1927 June, principally on the grounds that the variety of types was so large that it was impossible to classify them adequately without making further distinctions, and that the "edge-

* *Ap. J.*, **64**, 321 (1926).

on " spirals were incapable of accurate classification in either (*a*) or (*b*), or in any of their subdivisions.

A detailed reply to these criticisms was made by Hubble in the September number, and some further remarks by Reynolds appear in the November number of *The Observatory*, 1927.

A classification of nebulæ by K. Lundmark on very much the same lines as that proposed by Hubble is given in *Arkiv för Matematik, Astronomie och Fysik*, Band 19B, No. 8, 1926.

H.C.O. Bulletin 849 contains a classification of the extragalactic nebulæ by Shapley, specially suited to the Bruce telescope results, and dealing with integrated magnitudes, central condensation, and ellipticity.

Statistical Investigations on Extragalactic Nebulæ.—The second part of Hubble's paper in *Mt. Wilson Cont.* 324 consists of a general comparison of the diameters of 400 nebulæ, derived from photographs, with the integrated magnitudes found visually by Holetschek with a 6-inch refractor. A satisfactory correlation was found between the diameters and integrated magnitudes of the Elliptical class, E0 and E1, showing a reasonable agreement with the inverse square law, if diameters are considered. The spread of the points in the diagrams representing correlations in the Spiral class does not yield such satisfactory results, but it is doubtful whether any better results could have been expected where the material is not strictly homogeneous. A paper on the distribution in space of the extragalactic nebulæ, by R. Hess, appears in *A.N.*, 5561, dealing with the methods and conclusions adopted by Hubble.

A.N., 5482, contains a statistical study by A. Dose of the extragalactic nebulæ derived from the Königstuhl Catalogue of nebulæ, and a list of radial velocities and diameters of forty-four nebulæ of the spiral class (not necessarily " Spiralnebeln," as in the text).

A.N., 5573, contains an account of a new field of small extragalactic nebulæ found by W. Baade in Ursa Major near N.G.C. 3972. Sixty of these nebulæ are included in an area $16' \times 14'$.

Knut Lundmark has made an important contribution to nebular astronomy in a memoir communicated to the Upsala Royal Society of Science entitled " Studies of Anagalactic Nebulæ." This comprises an historical survey of investigations from Herschel's time, and epitomises present knowledge of surface brightness and integrated magnitudes, galactic distribution, spectra, proper motions, etc. It includes also diagrams of the distribution of " dark " galactic nebulæ from the Franklin Adams plates, and of the extragalactic nebulæ, besides plates illustrating Lundmark's measures at Mount Wilson of internal motions in M 33.

Galactic Nebulæ.—Comparative screened photographs of the Orion Nebula, showing images mainly of radiations $\lambda\lambda$ 3727/9 and $H\gamma$ and $H\delta$, obtained at the Helwân Observatory, are reproduced in *Nature*, 1928 February 11, by Reynolds, who points out that $\lambda\lambda$ 3727/9 are often either very faint or absent altogether in the planetary nebulæ, while a conspicuous radiation at λ 3869 in these spectra is at present unidentified.

Merrill in *P.A.S.P.*, **40**, 254, refers to the identification of λ 7325 with OII by Bowen, and mentions that this line appears in a spectrogram of N.G.C. 7027 by Wright. Theoretically this should consist of two powerful components and a weak satellite. Three spectrograms with the 100-inch reflector at Mt. Wilson give results which are sufficiently good to add confirmation to the identification.

In *P.A.S.P.*, **39**, 19, Gerasimovič discusses the luminosities of the nuclei of planetary nebulæ. The photographic luminosities are at least six magnitudes fainter than the normal O-type stars, if the trigonometrical parallaxes are correct. There are two possible explanations of this anomaly—either the faintness of the nuclear stars is real and they are white dwarfs of very high effective temperature, or the faintness is due to selective absorption by the nebular shell. Menzel in *P.A.S.P.*, **38**, 295, adopts the first alternative, but Gerasimovič points out that if the nuclei are as massive as normal O-type stars (Plaskett, $M = 40\odot$), then they must be 10^4 times as dense and the corresponding Einstein shift would be 70 km./sec., which is inconsistent with known data. Gerasimovič prefers the latter alternative—that the opacity of the nebular shell increases with the wave-length. In that case the shell must be extremely transparent for monochromatic radiations emitted by itself. Any satisfactory theory must reconcile this transparency with the general opacity to the longer wave-lengths emitted by the nucleus. A possible explanation based on the capture of electrons into orbits of high quantum number and expulsion from orbits of low quantum number is suggested.

Miscellaneous.—In *The Observatory*, **51**, 277, Prof. E. W. Brown outlines a mathematical theory of the spiral nebulæ based on Newtonian gravitational methods. This paper is a modification of an earlier paper in *Ap. J.*, **61**, 97, in which Van Maanen's measures were adopted.

Lindblad also discusses the nature of the spiral nebulæ in *M.N.*, **87**, 420.

Melotte in *M.N.*, **86**, 636, contributes a note on new nebulæ found on the Franklin Adams plates.

J. H. R.

The Society's Harrison Clock.

These notes upon the recent overhaul of the Society's Harrison clock should be regarded as supplementary to the account given by Mr. E. T. Cottingham in the *Monthly Notices* for 1909 November, which gives an excellent description of its mechanism. It may be noted that his account contains the first correct drawing of the "grasshopper" escapement ever published.

The clock was entrusted to me by the Society in 1927 April, I having undertaken to give such time as I could spare to cleaning and repairing it. The Society, on its side, undertook to defray my out-of-pocket expenses, the cost of such repair-work as I could not accomplish with my limited resources, and the expense of making a new case and pendulum.

When it came into my hands, the clock had not been going since 1910. It may be noted that prior to Mr. Cottingham's work on it in 1909 it had been stopped since about 1870. It appears to have been going from at least 1856 until that date, as I found scratched on the plates the name of one John Beresford, with the dates "1856 and 1860," and the address "84 Strand," indicating that Beresford was a workman in the employment of Charles Frodsham.

Having temporarily repaired the wooden pallets, which were broken, and fitted a cardboard fly to the remontoire train in place of the small and heavy copper fly which I found in it, I got the clock going and made a number of experiments to determine the most suitable driving weight, adjustment of the remontoire spring, etc. The clock was then taken down for cleaning. During this process, which occupied over a year, it was re-assembled from time to time to test various adjustments and repairs. Altogether, I have dismantled and re-assembled it five times. It may be noted that on the first occasion it took me nearly a week to get it together—and on the last occasion three hours in all. It contains some 540 parts.

The movement was found to be very dirty, dust and grime having made their way into the case in considerable quantities. As regards mechanical defects, in addition to the pallets and fly referred to above, the maintaining gear was found to have jammed, and the crutch to have cracked almost completely through. The remontoire was out of adjustment, and the fork of its detent cracked. There was a film of oxidation and soot over almost every part of the movement, and the cavities behind the various wooden rollers of the lantern pinions were partly filled with dust and dirt.

After some preliminary cleaning, the main plates of the movement were polished and lacquered and the dials resilvered, this work being carried out by the Gold and Silver Plating Co., Bayswater. The broken pallets were replaced by new ones, which I cut out of lignum vitæ after determining their length and angles by an enlarged model of the escapement. The pallets found in the clock were of mahogany, but I do not consider that they are the original pallets. Harrison habitually used (as in other parts of this clock) lignum vitæ, in conjunction with hard polished brass, to form a bearing or pivot which needed no oil; and I see no reason why he should have departed from this practice in his pallets. It may be noted that these lignum vitæ-brass pairs of surfaces are to be found all through this clock, and that in consequence no oil whatever is required for any portion of its mechanism.

It was found necessary to make an addition to the clock. If (as was ultimately the cause of its stopping in 1910) it is allowed to run down, it cannot, as originally designed, be restarted by merely rewinding it. The clock is not driven by its driving-weight, but by a small remontoire spring which that weight rewinds every half-minute. When the weight reaches the floor of the case, it has, of course, no longer any power to rewind the remontoire spring; but the latter continues to keep the escape-wheel turning until it has itself run down.

When, therefore, the clock ultimately stops, the remontoire spring has run down to such an extent that it will no longer keep the pendulum swinging. Merely rewinding the weight does not rectify matters—to do this, the detent of the remontoire has to be let off repeatedly when the escape-wheel is in the correct position for doing this. Such an adjustment requires expert knowledge of the clock mechanism.

As it was fairly certain that, if kept continuously going, the clock's weekly winding would in all human probability be occasionally overlooked, I designed a mechanism (based partly on one used by Harrison himself, and partly on one used by Ferdinand Berthoud in his second marine timekeeper) which should stop the escape-wheel shortly before the weight touched the bottom of the case. It is operated by the last turn of gut as this unwinds from the barrel, and "jumps" a small detent lightly into the path of the escape-wheel teeth, thus stopping the clock with the remontoire spring at its correct tension. As soon as the clock is rewound, the detent is automatically withdrawn, and the clock is ready to be restarted. The mechanism of this stopping-gear is practically concealed within the movement of the clock, and it is difficult at first sight to see that any addition has been made.

Apart from the fitting of this stopping-gear and the new pallets, the mechanism of the clock has undergone practically no alteration. The profiles of the cam which operates the remontoire detent have been slightly smoothed to give an easier lift to the detent, the detent-fork given a screw adjustment, and the fly replaced by one copied from the fly used in Harrison's No. 3 marine timekeeper. It may be noted that there is a very close resemblance between the mechanism of this timekeeper and that of the R.A.S. clock—in fact, they may be regarded as two similar movements, one controlled by a pair of balances and the other by a pendulum. In one respect, however, No. 3 is mechanically superior. Its remontoire gives an absolutely uniform torque at the escape-wheel, while the torque afforded by that of the clock varies, every half minute, in the proportion of n to $n - 1$, where $\frac{1}{8}\,n$ is the number of complete turns constituting the initial tension of the remontoire spring. Personally I am of opinion that while a remontoire was an absolute necessity in No. 3, the R.A.S. clock would perform practically as well with its remontoire out of action, especially since it has the most perfect train I have ever seen in a timekeeper.

The wooden pendulum found in the clock has been replaced by a gridiron pendulum of brass and steel rods, the gridiron being copied from that of an actual Harrison clock. It is obvious that Harrison, who invented the gridiron pendulum, would not have fitted a wooden pendulum to a clock of his own making so perfect in all other respects —such a proceeding would be analogous to completing a Rolls-Royce chassis by a body made of packing-cases. It is quite safe to assume, as I have assumed, that the wooden pendulum is a replacement, and that the original pendulum was a gridiron.

The "grandfather" case of the clock has been discarded. I am exceedingly doubtful whether it can be the original case. In the

first place, its sides have been cut away in two places almost to paper-thickness to allow for the swing of the bob—a proceeding which does not exactly suggest that the case was originally designed to house the movement. And, secondly, there are various features of the movement and of the plate carrying the pendulum, which strongly suggest that they were originally mounted on a wall.

In consequence, I designed a new case for the movement on the lines of a museum show-case with glass front, sides, and top, the movement being mounted on brass brackets screwed to an iron back-plate firmly secured to the wall of the Grove-Hills Library. This case admits of the movement being examined in detail from almost every point of view, and should be practically dust-tight. Provision is made for winding the clock (and, if necessary, setting the hands and restarting the pendulum) without removing the glass cover. I am hopeful that the clock will continue to go for many years in this case without any further attention except its weekly winding and occasional resetting of the day-wheel, whose operating mechanism does not provide for the short months.

I have not been able to determine the exact date at which Harrison made the clock. The only indication of a date (if it can be so regarded) which the clock affords is an inscription scratched on the maintaining spring—which, being rusty, has been replaced by a duplicate. This inscription reads "May 827." I can make nothing of it. From the clock's general lay-out, and by comparison of its mechanism with that of Harrison's No. 2, 3, and 4 marine timekeepers, I should be inclined to say that it was not made before 1740 or later than 1750, and that its most likely period of construction is 1745–1748.

Apart from its unique mechanism, the clock is of very considerable historical interest. There can be no reasonable doubt that it is the regulator which Harrison made for his own use. Both in his published writings and in an unpublished MS., of which I possess a copy, he constantly extols the merits of "my clock . . .," "a clock such as mine," etc., in comparison with the common regulators of his day, for the purpose of adjusting his marine timekeepers. The R.A.S. clock is the clock in question, and in consequence it must have played in its maker's lifetime a very considerable part in solving the problem of finding longitude at sea. The Society is to be congratulated upon possessing, in practically mint-state, so valuable a relic of the man who was England's greatest horologist and one of the world's benefactors.

In conclusion, I should like to pay a tribute to Mr. J. H. Agar Baugh, who undertook the making of the case and pendulum; to Mr. W. Buck, who was responsible for the re-conditioning of the plates and dials; and to Mr. R. J. Hopgood, who made the automatic stopping-gear and various small pieces for me. Their ready co-operation, and that of the Society's officials, has contributed very greatly to the success of the work.

R. T. Gould.

List of Public Institutions and of Persons who have contributed to the Library, etc., since the last Anniversary.

(*Institutions exchanging publications with the R.A.S. Library are omitted from this list, in order to economise in printing.*)

American Association of Variable Star Observers.
Baltic Geodetic Commission.
Barcelona, Observatorio Fabra.
Belgrade, Observatoire Astronomique de l'Université.
Benares, Mathematical Society.
Bern, Schweizerische Geodätische Kommission.
Cartuja (Granada), Estación Sismológica.
Chabot Observatory.
Colombo Observatory.
Firenze, Osservatorio Ximeniano dei PP. Scolopi.
Genève, Société Astronomique Flammarion.
Hamburger Sternwarte in Bergedorf.
Hyderabad, Nizamiah Observatory.
India, Meteorological Department.
International Astronomical Union.
International Geodetic and Geophysical Union.
Kharkov, Astronomical Observatory.
Kobe, Imperial Marine Observatory.
Kyoto, University Observatory.
Lembang (Java), Bosscha-Sterrenwacht.
Lemberg (Lwów), Observatorium der Technischen Hochschule.
Leningrad, Société Astronomique de Russie.
Liège, Institut d'Astronomie et de Géodésie de l'Université.
Liverpool, Astronomical Society.
London, Institution of Civil Engineers.
London, Society of Incorporated Accountants and Auditors.
Lourenço Marques, Observatorio Campos Rodrigues.
Manchester, Municipal School of Technology.
Mauritius, Royal Alfred Observatory.
Mizusawa, International Latitude Observatory.
Moscow, Society of Amateur Astronomers.
Nantucket, Maria Mitchell Association.
Netherlands, Indies Science Council.
Nishni-Novgorod, Verein von Freunden der Physik und Astronomie.
Oxford, Ashmolean Natural History Society.
Paris, Bureau International des Poids et Mesures.
Roma, Società Italiana per il progresso delle Scienze.
Rugby, Natural History Society.
South Africa, Astronomical Society.
South Africa, Director of Census.
Sydney University.
Tachkent, Université de l'Asie Centrale.

Tacubaya, Observatorio Astronómico Nacional.
Tennessee, Academy of Science.
Tiflis, Geophysikalisches Observatorium Georgiens.
Tokyo, Institute of Physical and Chemical Research.
Tokyo, Physico-Mathematical Society of Japan.
Toulouse, Académie des Sciences, Inscriptions et Belles Lettres.
Uccle, Observatoire royal et Institut royal météorologique de Belgique.
Upsala Observatory.
Varsovie, Institut d'Astronomie Pratique de l'Ecole Polytechnique.

Mrs. J. R. Abbott.
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Signor P. Emanuelli.
M. R. Esnault-Pelterie.
Signor G. Favaro.
Mme. Flammarion.
The Rev. D. R. Fotheringham.
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Mrs. Isaac Roberts.
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Herr E. Schoenberg.
Dr. H. Shapley.
Señor E. Sifontes.
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Dr. P. Stroobant.
Prof. S. D. Tscherny.
Prof. H. H. Turner.
Dr. J. Voûte.
Messrs. Wheldon & Wesley.
Dr. W. H. Wright.
Prof. I. Yamamoto.

ADDRESS

Delivered by the President, the Rev. T. E. R. Phillips, on presenting the Gold Medal of the Society to Professor Ejnar Hertzsprung, for his Determination of the Distance of the Lesser Magellanic Cloud.

On looking through the list of those on whom the Society has conferred its highest honour we note that the grounds on which the award has been made have differed widely. Sometimes it has been for a long and laborious, though straightforward, piece of work; sometimes for an original discovery; sometimes for the enunciation of a new theory; sometimes for the designing and construction of a new instrument; sometimes for the compilation of a catalogue, etc. To-day I have to lay before you the grounds on which the Council has awarded the Gold Medal to Professor Ejnar Hertzsprung. To do this in a short address is not easy, for his work has been of an extremely versatile character, and includes researches in photography, photometry, star colours, effective wave-lengths, absolute magnitudes, proper motions, radial velocities, the Sun's motion, stellar parallaxes, variable stars, double stars, clusters of stars, and the determination of the distance of the Lesser Magellanic Cloud.

But although these subjects might appear at first sight to be rather disconnected, yet there can clearly be traced through a great part of Professor Hertzsprung's researches the influence of one great desire, viz. to find, if possible, in the nature of the light which we receive from the stars such observable peculiarities as might afford a clue to their real brightness. For not only is this latter information a matter of high importance in the study of the stars themselves, but if it can be obtained the distances of remote stars can at once be calculated from a comparison of their *real* with their *apparent* magnitudes. And in making this award the Council has laid special emphasis on the study of the real brightness of Cepheid variables and the application of the results found to deduce the distance of the Lesser Magellanic Cloud—a discovery which paved the way for further important researches by other astronomers.

For the sake of completeness I may, perhaps, at this point recall the fact that by the expression "absolute brightness" or "absolute magnitude" is denoted the brightness a star would have if viewed from a standard distance. But whereas the distance now generally assumed is 10 parsecs, corresponding to a parallax of $0''{\cdot}1$, Professor Hertzsprung has adopted that of 1 parsec or $1''{\cdot}0$. The absolute magnitude (M), the apparent magnitude (m), and the parallax (π) of a star are then connected together by the relation

$$\mathrm{M} = m + 5 \log \pi,$$

so that if the parallax is known, its absolute magnitude can be found; or if, on the other hand, the absolute magnitude can by some means be

determined, then the parallax is at once deducible—the apparent magnitude being an observed quantity.

But in seeking to calculate absolute magnitudes from parallaxes we encounter the difficulty that in the majority of cases the stars are so remote that their required parallaxes are too small to be measured. We may, however, get round this by taking their proper motions as, on the average, a fair indication of their distance; and though, of course, not strictly trustworthy in particular cases, yet the results found for groups or classes of stars may be relied on as about right. The equation I mentioned just now then takes the form

$$H = m + 5 \log \mu$$

where μ is the annual proper motion.

A great deal of Professor Hertzsprung's work, and of what has come from it, depends on this relation.

Another subject connected with star-light which has engaged much of his attention is that of *colour*. But since, in the great majority of cases, the direct visual determination of this is impossible, and at best can be but rough, other and more accurate means of determining colours or their equivalents are employed. Amongst these is the measurement of a star's *colour index, i.e.* the difference between its photographic and its visual or photovisual magnitudes. Another is the measurement of *effective wave-length* by photographing the stars with a coarse grating placed in front of the object-glass or mirror and measuring the distance between the corresponding points of maximum intensity in the lateral spectral images, which will vary with the colour of the star. The use of such a grating was suggested by Schwarzschild in 1896, and its value for the measurement of effective wave-lengths has been fully shown by our Medallist while at Copenhagen, and by Bergstrand at Upsala. Professor Hertzsprung's earliest paper on effective wave-lengths was published in 1908 (*Bull. Astron.*, **25**, 5) under the title "*Sur la dispersion atmosphérique*" in connection with Bergstrand's investigation of the parallax of 61 *Cygni*, and many of the papers which have been considered by the Council in making to-day's award have been concerned with results obtained by the method I have mentioned.

I may add that it was at Professor Hertzsprung's suggestion that the effective wave-lengths of the stars of the *Astrographic Catalogue* between the Pole and 80° N. declination were determined at Greenwich by the use of a coarse grating in conjunction with the 30-inch reflector. At the present time a number of bright stars are being investigated at Greenwich for the determination of stellar temperatures, and these will be observed for effective wave-lengths by Mr. F. J. Hargreaves at Kingswood.

It is also to be noted that Professor Hertzsprung has made considerable use of the objective grating for general photometric purposes by applying the known ratio in brightness between the central images and the first order spectra.

I turn now from these introductory remarks to the consideration of

some of our Medallist's actual achievements, and first I will refer in more detail to that feature of his work which I have already mentioned, viz. his constant search for indications of a star's absolute brightness in some characteristic of the light which it emits.

"If only we could from the spectrum of a star," he wrote several years ago, "deduce its absolute magnitude, we could from the apparent magnitude and the spectrum calculate the parallax." "Strictly, any alteration of absolute magnitude, whatever its cause, must show itself in some way in the spectrum, even if certain circumstances, *e.g.* surface area, may have a large influence on its absolute magnitude without much influence on the spectrum." "There are yellow stars which differ enormously from one another in absolute magnitude for which no spectral differences are known. It will be specially valuable to discover such spectral differences."

But it is to be noted that these same thoughts were in his mind even in the early days of his astronomical career when he was working at the Urania Observatory, Copenhagen. Among his papers published at that time were two (1905 and 1907) of outstanding merit on the radiations of the stars, but unfortunately their real value did not then become very widely known to astronomers, owing to the fact that they were published in a photographic journal—*Zeitschrift für Wissenschaftliche Photographie.*

In the researches therein described attention was given to the characteristics assigned by Miss A. C. Maury to the spectra of stars in her system of classification. It will be recalled that her main groups—22 in number—were subdivided into the following classes :—

Spectra with sharp lines—denoted by the letter *c*.
Spectra with broad lines—denoted by the letter *b*.
Spectra with lines intermediate between those of *b* and *c*—denoted by the letter *a* ; and spectra with lines intermediate between those of *a* and *c*—denoted by the combination *ac*.

Now after investigating the absolute magnitudes of certain stars and pointing out the enormous differences in the luminosities of stars of the same spectral type, *e.g.* 61 *Cygni* and *α Tauri*, or Capella and the Sun, he wrote : "The question now arises whether it may not be possible to discover spectral equivalents of such differences of intrinsic brightness—small differences in the spectrum associated with great differences in brightness—and. in particular, whether the subdivisions *a*, *b*, *c* of Miss Maury are such equivalents." Testing the matter by means of Kapteyn's proper motions he found that, although there was no systematic difference between the proper motions reduced to 0^m for the subdivisions with the *a* and *b* characteristics, the proper motions of stars with the *c* characteristic were almost imperceptible, showing them to be at immense distances from us and consequently extremely bright. In fact, in order to make their apparent magnitude zero, he found their parallaxes would have to be $+ ''\cdot 003 \pm ''\cdot 003$.

The smallness of the proper motions of these stars is strikingly shown by the following table, in which the third column gives what would

be the normal proper motions for stars of the same spectral types with the *a* and *b* characteristics, and the last column those actually observed.

Star (with *c* Characteristic).	Harvard Rev. Mag.	Centennial Proper Motion.	
		Normal for Stars with *a* and *b* Characteristics.	Observed.
		″	″
2H Cam.	4·42	6·79	·65
ε Aur.	3·35	25·59	1·52
β Ori.	0·34	35·16	·24
o_2 CMa	3·12	4·72	·25
δ CMa	1·98	130·62	1·06
η CMa	2·43	6·49	1·45
η Leo.	3·58	7·41	·68
67 Oph.	3·92	3·27	1·31
v Sgr.	4·01	6·49	·48
γ Cyg.	2·32	111·69	·43
α Cyg.	1·33	23·77	·44
ϱ Cas.	4·85	34·83	·70

It seems that in this enquiry we have the first definite suggestion of the connection between the absolute magnitudes of stars and the characteristic lines in their spectra—in other words, the real beginning of the method which in recent years has been applied with such remarkable effect in the determination of what are termed "spectroscopic parallaxes," and which, it seems, is destined to do far more in the future in extending our knowledge of the distances and distribution of the stars. It is also interesting to note the reference to the fact that, according to Miss Maury's remarks, the line 0·40779μ is generally stronger in the stars of which the deduced proper motions are small, and that this line is also somewhat stronger in the spectrum of α *Aurigæ* than in that of the Sun, which is in agreement with the greater absolute brightness of α *Aurigæ*. The line mentioned is one of the strontium lines so largely used in the determination of spectroscopic parallaxes to-day.

There is another point in connection with Professor Hertzsprung's study of stars with the *c* characteristic which I must not overlook, and it is one which provides a striking illustration of his versatility. He remarked that as a consequence of their remoteness and almost complete freedom from proper motion, the constant of precession could be obtained as accurately from a dozen of these stars as from 1000 fundamental stars with proper motions equally well determined.

I must now make a short reference to some of Professor Hertzsprung's studies of star clusters. It will, of course, be readily appreciated that since we have precise information about the parallaxes of so few of the stars—comparatively speaking—clusters of a compact nature afford a specially valuable means of studying the relations

between colour and luminosity. For in such cases the physically connected members are readily distinguished by their compactness and their community of motion from other stars belonging to the background of the sky, and, moreover, they can all be considered as being at substantially the same distance from us. A careful study was accordingly made of such clusters as the *Pleiades*, the *Hyades*, and *Præsepe*, as well as of other groups of stars like the *Ursa Major* system. It will be quite impossible with so much before us to consider the results he has obtained for these objects in detail, but I will quote the following summary of some of his conclusions from *Bulletin No.* 25 of the *Astronomical Institutes of the Netherlands* :—

"If we consider," he says, "the six most prominent known star clusters, viz. the *Ursa Major* group, the *Hyades*, the *Pleiades*, *Præsepe*, χ *Persei*, and *h Persei*, it is interesting to note that they are, in general, different from each other in statistical constitution. The Ursa Major group consists of absolutely bright not very different stars, of which a great proportion are spectroscopic binaries. There is a marked absence of faint members in this system. On the other hand, the brightest stars of the *Pleiades* are of spectrum B5, with increasing numbers of members of classes A and F. Further, the two similar twin clusters χ and *h Persei* show a new feature, the brightest members being of the peculiar spectral subdivision *c* of Antonia C. Maury. Finally, the *Hyades* and *Præsepe* are again markedly different from the other clusters, but very similar to each other. They both, in addition to a main 'normal' series of stars gradually changing in magnitude and colour, contain a small group of absolutely bright yellow so-called 'giant' stars, entirely deviating from the rule." The significance of some of these remarks will be developed a little later in my address.

Another important piece of work, the account of which was published in 1915, was the determination of the effective wave-lengths of 184 stars in the cluster *N.G.C.*, 1647. The photographs were taken with the 60-inch reflector at Mt. Wilson, stopped down to 40 inches to increase the size of the field available for accurate study. Two kinds of plates were used, and after a careful comparison and discussion of them a list of the stars was published with their respective colour indices. In this discussion of the results attention is drawn to the paucity of white faint stars, the general conclusion being that the fainter the stars in the region under examination the greater the minimum effective wave-length, which is in agreement with what is known about the distribution of the stars in general and the relation between absolute brightness and colour.

But more valuable and extensive than the research just mentioned was Professor Hertzsprung's study (for which the 60-inch reflector at Mt. Wilson was also employed) of the effective wave-lengths of the Pleiades. Now since this cluster has been particularly well observed, and a number of old photographs are available for comparison with modern plates, the purpose in view in this investigation was not merely to find the relation between absolute magnitude and colour for members

of the cluster, but also to gain information concerning the colour equivalents of as faint stars as occur on the old plates which are suitable for the determination of relative proper motions. The work involved the measurement of nearly 10,000 effective wave-lengths, and the paper includes a catalogue of 1246 stars, as well as a map of the cluster (*Mém. de l'Acad. Roy. des Sciences et des Lettres de Danemark, Sect. des Sciences,* 8me sér., t. **4**, No. 4, 1923).

Yet another and extremely important research relating to this same subject was published in 1922, and includes a catalogue of 734 stars brighter than the fifth magnitude within 95° of the North Pole, with their mean colour equivalents and other details. The material used was taken from a very heterogeneous collection of sources, including the published visual estimates of star colours by a number of observers (Osthoff, Krüger, Lau, Müller, Kempf, and Hagen); measurements of colour by comparison with an artificial source of light, the effective temperature of which could be controlled (Wilsing); the differences between visual and photographic magnitudes (King, Draper Catalogue, and Göttingen Actinometry combined with the visual magnitudes of Harvard and Potsdam); monochromatic photometry of selected spectral regions (visual by Wilsing and Scheiner, spectro-photographic by Rosenberg, photo-electric by Guthnick); and photographic determinations of effective wave-lengths derived from short grating spectra (Lindblad).

With material so diverse as this it was clearly necessary to adopt a standard scale and devise methods of treating the various series of observations so as to bring them into line with it. Formulæ for this purpose were derived and the whole of the material reduced to Wilsing's scale. All the results were then expressed in terms of c_2/T, where the constant c_2 = 14,600°, and T = the absolute temperature of the star. Some interesting results were deduced in the discussion which followed, including the fact that 99 per cent. of the values of c_2/T lie between 1 and 5, which shows how few, comparatively speaking, are the stars which have surface temperatures above 14,600° on Wilsing's scale. The maximum frequency occurs at c_2/T = 1·4, which corresponds to spectral types B and A, and there is a second maximum at about 3·25 corresponding to type G7. There is a minimum at 2·85, and after 4·6 the series rapidly comes to an end. Taking the stars all together, the median value of c_2/T is 2·27, and the mean value 2·50. The fact that the figure for our Sun is 2·47 shows that it is of about intermediate colour among the naked-eye stars.

An interesting question which arises in this investigation is that of the *distribution* of stars of different colours. So far as mere *apparent* brightness goes there is no indication among these 734 stars of any systematic variation of colour with magnitude, but is the same thing true if *absolute* brightness is considered? Making use of their known proper motions, Professor Hertzsprung obtained results for all these stars which are set out in an instructive diagram, with values of c_2/T from zero upwards as ordinates and magnitudes reduced to the unit of proper motion as abscissæ.

The diagram shows in the lower part the whiter or hotter stars in a slightly inclined band, indicating diminishing temperature with diminishing luminosity, separated by a gap from the bright stars of the *α Bootis* and *α Tauri* type. There is accordingly a well-marked division of the bright stars into two groups termed by Professor Hertzsprung "white" and "yellow," while stars of intermediate colour are scarce, a result in agreement with that already obtained in the study of the *Hyades* and the *Præsepe* clusters. Such bright stars as there are of intermediate colour are mainly stars of very great luminosity, including the variable stars of the *δ Cephei* type; and the suggestion is made that, if Lockyer's scheme of stellar development is adopted, these latter stars may represent a short transitional stage between the bright yellow and the bright white stars.

Another particularly interesting result derived in this study of colour equivalents and absolute magnitudes of stars is that of their *hypothetical angular semi-diameters*. For this purpose the fact that our sun radiates practically as a black body is regarded as justification for applying the known laws of black-body radiation to the stars in general. Calculating the stellar magnitude of the surface brightness on this hypothesis for the various values of c_2/T occurring amongst the stars, Professor Hertzsprung obtained the following formula for computing the corresponding semi-diameters (ρ):—

$$5 \log \sin \rho = -43{\cdot}44 + 2{\cdot}3(c_2/T)^{{\cdot}93} - m_{vis}.$$

It is worth noting that apart from slight alterations in the constants this is the same formula as was found by him in 1906, and by means of which at that early date he calculated the angular diameter of Arcturus to be 0″·05—a result which has since been satisfactorily confirmed.

In the general catalogue of the 734 stars now considered, the deduced angular semi-diameter is given for each of the stars. It is true that only in three instances (viz. those of *α Orionis*, *α Tauri*, and *α Bootis*) does the value exceed 0″·01, but there are nearly a score of others which approach it, so that although the great majority of the stars are hopelessly beyond the present reach of interferometer measurement, many interesting observational results may be expected from the great instrumental developments which appear likely in the near future.

I must now return to the important discovery of 1905—which I have already mentioned, incidentally, as arising out of the search for absolute magnitudes. It was a discovery of capital importance in cosmical physics, and one which became later a cause of considerable perplexity to astronomers, inasmuch as it involved the upsetting of ideas which had gained widespread acceptance. Apart from the stars with the *c* characteristic already referred to as very distant and very bright, Professor Hertzsprung found, from an examination of the proper motions of the stars for which Miss Maury had determined the spectral types, that whereas the absolute magnitudes of the whiter stars of types B, A, and F as far as F8 followed one another in the recognised sequence, in type G there suddenly appeared a division in

the stars. There was the continuation of the sequence just mentioned, into which the Sun fitted well, and to which the name "Sun series" was given, and there were also a number of *absolutely bright* stars. This division between the absolutely bright and the absolutely fainter stars was also widely marked in the "later" types K and M, but although it was found that the "Sun series" soon died out as far as naked-eye visibility was concerned, an examination of the stars within a given distance—say 10 parsecs—from the Sun has shown that the fainter stars are much more abundant than the bright stars per unit volume of space. The terms "giant" and "dwarf" are now usually applied to these two classes of absolutely bright and absolutely faint stars; and in this connection it is interesting to recall the fact that many years ago Professor Hertzsprung spoke of the intensely bright *c* stars as "whales among the fishes."

But to appreciate the full significance of the discovery we must recall the fact that at the time the Harvard classification B, A, F, G, K, M was generally regarded not only as representing the sequence of spectra but as indicating the order of stellar evolution. In other words, it was believed by many astronomers that stars born from nebulæ begin their stellar existence as bluish or white, and then pass successively through the colour stages of yellow, orange, and red, with diminishing lustre to the condition of non-luminous bodies. But how could this theory—which appeared to be well supported by observational evidence—be reconciled with the existence of these very bright stars at the bottom of the scale? However, the reality of the two classes of stars was beyond doubt, and the work of their investigation was carried on with great energy by Professor H. N. Russell as well as by Professor Hertzsprung. No doubt there are several Fellows present this evening who recall something of the thrill which was felt when, at our meeting on 1913 June 12, Professor Russell gave an address on this subject, and showed us that historic diagram now known all over the world as "the Russell diagram." Since then further thrills have been experienced and further problems raised. For example, there has been the discovery of the white dwarfs, and the problem of their physical state and where to place them in the general scheme. And then the establishment of the mass-luminosity relation by Professor Eddington has raised the question as to whether that familiar curve with its ascending and descending branches of spectral types in the order M, K, G, F, A, B, A, F, G, K, M, now seen to be an order of diminishing masses, can any longer be regarded as actually describing the evolutionary career of a single star. And then there has been the thrill of the conception (though it was actually suggested by Sir James Jeans more than twenty years ago) which seems to save the evolutionary idea, viz. that of the actual annihilation of stellar material by the falling together of protons and electrons within the atoms of a star, so that its very substance is being ceaselessly dissipated in streams of radiation. It is all very wonderful, but we note the important part which the pioneer work of our Medallist has played in the development of our conceptions of cosmical physics.

But of all the researches of Professor Hertzsprung in the realm of stellar radiation and absolute magnitudes none has, perhaps, been more striking or provided a more effective method of sounding the depths of space and determining the distances of the more remote parts of the Universe than that which led to the achievement particularly mentioned by your Council, viz. his determination of the distance of the smaller of the two Magellanic Clouds. The story begins with a very important discovery by Miss Leavitt at Harvard, which is described in *Harvard Circular*, 173 (1912 March 3). She had been studying the variable stars in the Smaller Cloud and found 25 whose behaviour was similar to that of cluster variables. They diminished in brightness slowly, paused near minimum, and then rose rapidly to a brief maximum. But the most interesting point about them was the evident connection between their periods and their brightness. On plotting the logarithms of the periods against their maximum and minimum light she found a simple linear relation, the logarithm of the period increasing about 0·48 for each increase of 1 magnitude in brightness with a mean deviation of the individual stars from the formula of only $0^{m}\cdot27$. Now here was another clue of which our Medallist was quick to take advantage. He saw that these 25 stars could be regarded as practically all at the same distance from us, and that consequently their periods of variation were related to their *absolute* as well as to their apparent brightness. He accordingly turned to the bright Cepheids, whose proper motions had been determined, and deducing from the mean parallactic components of their motion the parallaxes and luminosities of 13 stars, found the required constant in the relation between period and absolute brightness. It was then a simple step to the computation of the absolute magnitudes of Miss Leavitt's Cepheids in the Smaller Magellanic Cloud and then, from the relation I mentioned earlier, the distance of the cloud in which they appear. It came out as 10,000 parsecs or 33,000 light years. More recent investigations have led to a distance considerably greater than that assigned by Professor Hertzsprung in 1913, but the really important point is that his work placed a new power in the hands of astronomers which they have successfully applied with great skill to other and still more remote objects, viz. the Globular Clusters and the Spiral Nebulæ. Indeed, Dr. H. Shapley has devised important extensions of the method by which he has determined the distances of Globular Clusters in which no variable stars have yet been found, but he has made due acknowledgment in his account of those researches of the pioneer work of Professor Hertzsprung (*Mt. Wilson Contributions*, No. 151).

As regards the many other investigations which our Medallist has carried out, the limitations of time forbid me to do more than refer hastily to a few of them. Of course, as is only natural in the case of one so interested in stellar radiation, variable stars—though only those of short period—have received a due share of his attention. Where his papers are so numerous it is difficult to make a selection, but I would specially mention his accurate work on the light-curves of *S Sagittæ* (*A.N.*, 4916), *VV Orionis* (*Potsdam Publ.*, No. 73), and his

photographic study of *RR Lyræ* (*B.A.N.*, No. 24), the latter being the brightest variable star of the cluster type known. On this star nô less than 1010 exposures were made, 3 mm. within the focus, on 39 nights with the Potsdam Zeiss Triplet lens. But of all his discoveries, certainly one of the most interesting was his photographic demonstration of what had been suspected by Pannekoek, viz. the variability of Polaris. It must surely have been with feelings of considerable satisfaction and not a little amusement that he found himself able to announce (*A.N.*, 4518) this discovery, for had it not been said that Polaris "is perhaps the star in all the sky of whose constancy in light we may be the most certain"? During the last few years he has been working in collaboration with the Johannesburg Observatory, and during a stay at that Observatory he took no less than 1792 plates with the Franklin Adams instrument, covering a total exposure time of 638 hours. He has also published up to date 36,000 estimates of brightness on Franklin Adams plates, and has determined over one-third of the Ephemerides of short-period variables of the Eclipsing, Cepheid, and Cluster types added to the Astronomische Gesellschaft's list during the past five years. In addition, while paying a visit to Harvard he made, between 1926 October and the following May, 12,000 estimates of the brightness of variables on plates taken with the 1-inch Cooke lenses. Half of these stars were Cepheids and the remainder eclipsing variables.

There is one star of the Algol type about which Professor Hertzsprung so long ago as in 1909 came to some particularly interesting conclusions, viz. ϵ *Aurigæ*. This is a star with the *c* characteristic, and he has described it as a gaseous sphere with a diameter equal to that of the Earth's orbit, a mass about equal to that of the Sun, and a density accordingly of about one-millionth part that of the latter body.

As regards the Cepheids, I must refer to a very interesting paper of his on the form of the light-curve and the length of the period of these stars. It had already been remarked by Ludendorff (*A.N.*, 5006) that the proportion of the curve during which the brightness is increasing varies with the period, the curves of stars which go through their changes in between one and two weeks being the most symmetrical. In following up this clue 37 stars were selected, the curves of which have been well determined (many of them by Professor Hertzsprung himself or by his pupils), and are distributed over nearly the whole range of period known for variables of this type, the cluster variables with periods of about half a day being omitted. The curves were all reduced to the same scale, and a series of diagrams drawn and arranged in order of length of period. It was at once seen that the forms of the curves are not distributed at random. Thus, for periods up to about 6 days there is the usual δ *Cephei* variation with quick rise and slow decline. Above 6 days a secondary wave makes its appearance on the descending branch shortly after the maximum is passed, and produces the appearances of a secondary maximum. The curves of η *Aquilæ* and *S Sagittæ* are typical. For periods between 10 and 13 days the secondary wave is situated on the top of the ordinary maximum, and the

curve rendered more nearly symmetrical, characteristic examples being the light-curves of *AQ Carinæ* and *Z Lacertæ*. The superposed maximum occurs still earlier at periods between 14 and 15 days, and produces a hesitancy in the increase of brightness about midway between minimum and maximum, while at periods greater than 16 days there is commonly a return to the δ *Cephei* type of curve with quick rise and slow fall.

In the field of double-star astronomy a very important piece of work (of a pioneer character) was carried out during the time Professor Hertzsprung was at Potsdam, and is described in vol. xxiv., part 2, of the *Publications* of that Observatory. Between 1914·0 and 1919·4 he made no less than 16,680 exposures on 408 plates of 126 double stars. The instrument employed was a visual refractor of 50 cm. aperture, and the plates, the scale of which was 1 mm. = 16″·4, used were sensitive to green and yellow light of mean wave-length about 5450 Å. A colour filter was used to transmit a small part of the spectrum near the wave-lengths for which the visual objective was made achromatic. The account given of the work indicates the extreme care that was taken in eliminating or overcoming the various sources of error in work of this kind, such, *e.g.* as would arise from atmospheric dispersion on images of somewhat different colours and the vagaries of photographic action in the process of development, and so forth. One device calls for special note. To avoid errors associated with differences in brightness between the two components of a pair, a suitable grating was employed to render the first-order diffracted images of the bright component approximately equal to the central image of the fainter one. In making and reducing the measures the position of the mean of the two diffracted images of the brighter star was adopted instead of the central image. The measurements of the plates show extremely small mean errors, and, as illustrating the very high standard of precision at which, in Professor Hertzsprung's view, astronomers should aim, I quote his statement that the same accuracy should be reached in double-star measures as in the determination of parallaxes. There can be no doubt that his work has brought out in a remarkable manner the possibilities of photography in this field, though doubtless for very close pairs—say, those under 1″ separation—we must continue to depend on visual measures.

On the theoretical side we find in *A.N.*, 4975, a formula by Professor Hertzsprung for calculating the hypothetical parallaxes of double stars of known orbital motion, in which the relation between mass and absolute brightness is taken into account. We also note that (like Professor H. N. Russell) he devised a method of calculating hypothetical parallaxes for double stars of which the orbital motion is slow and the observed arcs accordingly too short for reliable elements to be computed, and he has pointed out that once the mass is adopted the formula can be used to give a minimum value for the parallax. In his formula the combined mass of the components is assumed equal to the Sun's mass, and a comparison with stars whose parallaxes are known led to the conclusion that the true parallax of a binary system

is about double the minimum hypothetical parallax so derived, the mean error being about one-third of its value.

The calculation of hypothetical parallaxes has more recently been extensively carried out by Dr. J. Jackson and Mr. H. H. Furner, using similar formulæ.

Among his miscellaneous studies I must not omit to mention that which led to the addition he made twenty years ago (*Ap. J.*, **30**) to our knowledge of the *Ursa Major* group. It had been found by R. A. Proctor that five of the stars of the Plough, viz. β, γ, δ, ϵ, and ζ, had similar proper motions and were probably travelling through space with nearly equal and parallel velocities. This was confirmed later by the observations of their radial motions by various astronomers, and the system was subsequently investigated by Ludendorff. But Professor Hertzsprung succeeded in identifying other stars in widely separated parts of the sky as members of the same physical system. Taking Kapteyn's discussion of the Bradley stars, he compared the observed directions of motion with the proper motion each star would have on the supposition that it belonged to the system. Of those which showed the most promising agreement he selected a number for comparison with the *New Fundamental Catalogue* of the Berlin *Astron. Jahrbuch.*, and finally selected six, of which *Sirius*, α *Coronæ Borealis*, and 37 *Ursæ Majoris* appeared the most certain, as members of the group, with two others as probables. The motion of the system is nearly in the plane of the Galaxy, and as its convergent point is so far from the apices of the two star streams and from that of the Sun's motion the members of the group could be readily distinguished. Professor Turner has drawn attention to an interesting fact about this scattered system of stars. It is a remarkably flat disc with its plane approximately at right angles to the direction of its motion.

I fear this address has already reached an inordinate length, for which I feel I must largely blame Professor Hertzsprung for his enormous output of work. Indeed, there are many other important papers of his which I am compelled to leave entirely alone, including those dealing with the brightness of the nebulosity surrounding the Pleiades, photographic magnitudes of the faint Pleiades, and of the Præsepe stars, his study of the globular cluster Messier 3, his confirmation of the existence of the dark body announced by Nörlund in the system of ζ *Ursæ Majoris*, and his work on the motion of the Magellanic clouds. As a matter of fact, I suppose there are few astronomers—at any rate in recent times—who have done original work in so many different fields, and done it with such conspicuous success. But one thing which emerges in a general review is that he has contributed to the progress of the science not only by reason of the originality of his ideas, and his alertness to perceive and follow up a new clue, but also by his thoroughness and his ingenuity as a practical observer. Many of the papers I have attempted to describe this evening illustrate this fact; but as additional evidence of his capacity for obtaining the best possible results in his observational work I will draw attention to the following: In his photographic observations of *S Sagittæ* he

availed himself of the fact that reproduction plates differ from ordinary plates in the opposite direction to that in which visual observations do. And since, in the case of the Cepheid variables, the photographic range is larger than the visual, it occurred to him that a still greater range might be obtained by the use of reproduction plates. That actually found was 1·5 times as great as the visual range.

I must also mention his successful treatment of the problem which presents itself in photographic work of special delicacy when images of different brightness are encountered. It is one of the difficulties in determining the effective wave-length of a star that the effect changes with the strength of the image; but by taking photographs with exposures ranging from 15^s to 2^h he made a thorough study of the growth of the images and reduced the measures to a standard scale.

Yet another point to be noticed in connection with his practical work is his use of a prism in conjunction with a grating to determine the energy distribution in different parts of the spectrum. This method has since been brought into use at Greenwich. But there is another fact which has doubtless contributed substantially to his success, viz. his readiness to adapt himself to the capacity of the apparatus he has had for the time being to use. He has himself put the matter in this way: "When I had an instrument at my disposal I asked myself, What is that machine specially suited for? instead of trying to apply it to what I would like in the first place specially to do. For instance, I should have liked to find the spectral differences between 'giants' and 'dwarfs' of the same spectral class with the Zeiss Triplet at Potsdam, but the instrument was too small for reaching a satisfactory number of absolutely faint stars. On the other hand, the objective was transparent to ultra-violet radiations, therefore I devoted it to photometric observations of δ *Cephei* stars." And he has given us as an instance of the effectiveness of the instrument for this type of work the fact that the range of Polaris was found to be two or three times as great as with the selenium cell. It is to his sound judgment in making the best possible use of the opportunities presented to him, as well as to the originality of his ideas, that his great success is to be attributed.

Professor Hertzsprung has worked in various countries and at a number of observatories—Copenhagen (Urania Observatory and later at the University Observatory), Göttingen, Potsdam, and now Leiden, and he has also visited for particular purposes Mount Wilson, Johannesburg, and Harvard—but I think he would like me to say that he is proud to be by birth and nationality a Dane. Denmark is not a very large country, but it has given to the world a number of distinguished men. In our own department of science we recall the great names of Tycho Brahe and of Römer, and that of a recent compatriot by birth of theirs—the late Dr. J. L. E. Dreyer—Past President and recipient of the Gold Medal of our Society, who, in addition to all else that he did, has edited and given to the world in fourteen beautiful volumes (the last two published after his death) Tycho's *Omnia Opera*.

And this evening it is our great pleasure to welcome among us once

again Professor Hertzsprung—an Associate of the same nation and tradition—and to do honour to him for the splendid work he has accomplished.

Professor Hertzsprung, I ask you to accept this medal as a token of the very high appreciation with which your researches are regarded by British astronomers, together with our very sincere good wishes for their long continuance.

The following report was received too late for it to appear in its proper place :—

Sydney Observatory.
(Director, Mr. James Nangle, Government Astronomer.)

The work on the Astrographic Chart, which forms the main programme of this Observatory, has progressed steadily, although on a much reduced scale as compared with what was being done for some years previous to 1927. The programme now in operation provides for the transit observations and reduction of 2000 plate stars per year, with a corresponding rate of progress in plate measures, computation of plate constants, and preparation of matter for printing. At this rate the Sydney zones of the Astrographic Catalogue will be completed in about nine years from the present time. During 1927 the number of transits of plate stars observed was more than the rate allowed. This year, however, in spite of the best efforts of the Chief Assistant, Mr. W. E. Raymond, the number has been less, owing to extraordinarily adverse weather. The average, however, has been maintained. The last plate for the Astrographic Catalogue was successfully taken just recently, so that this section of work is now complete. There are now four volumes of the Catalogue ready for the printer. Two of these volumes, namely, V and VII, embracing right ascensions from 0^h to 12^h in declination $-53°$, are actually in the press. The proofs are now being checked and the volumes should be ready for distribution during 1929. Work is being continued with the astrograph in the taking of chart plates. The photography of the chart is only about half completed.

During the year the re-determination of the latitude of the Sydney Observatory has been carried out by the Director and the Assistant Astronomer, Mr. W. C. Graham. This work, which has been done without any interference with the programme of work on the Astrographic Catalogue, was carried out at the request of Dr. Duffield, the Commonwealth Astronomer at Canberra. The re-determination is to be used as a means of re-determining the latitude of Brisbane's Observatory at Parramatta, the relative positions of the two observatories having been accurately measured by the Surveyor-General of New South Wales, Mr. H. B. Matthews. The results are not finally reduced, but it appears likely that there will be no measurable change since the time of Brisbane.

The programme includes systematic provision for visits to the Observatory by members of the public. Altogether 602 visitors attended during the year. On good nights they have seen through the large equatorial, and on cloudy nights they have had lantern lectures. This part of the programme is intended to provide popular education in astronomy and to familiarise the public with the work of the Observatory. The routine work of the time services for the State, including daily transmissions of wireless time signals, the recording and reduction

of earthquakes, and the reduction and preparation of astronomical memoranda for public use, has been satisfactorily carried on.

With the exception of the clock vault, the Observatory buildings have been completely renovated during the last two years, and the equipment has been thoroughly overhauled and put in good order. With regard to the clock vault, steps will have to be taken in the near future to provide for better temperature conditions. The Sidereal clocks, including the No. 8 Shortt Synchronome, have been giving unsatisfactory rates.

Election of Officers and Council.

The following Fellows were elected as Officers and Council for the ensuing year :—

President.

A. C. D. Crommelin, Esq., B.A., D.Sc.

Vice-Presidents.

Sir Frank Dyson, K.B.E., M.A., D.Sc., LL.D., F.R.S., Astronomer Royal.
E. B. Knobel, Esq., D.Sc.
H. F. Newall, Esq., M.A., D.Sc., F.R.S.
Rev. T. E. R. Phillips, M.A.

Treasurer.

J. H. Reynolds, Esq.

Secretaries.

Herbert Dingle, Esq., B.Sc., Asst. Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.
H. Knox-Shaw, Esq., M.A., D.Sc., Radcliffe Observer, Oxford.

Foreign Secretary.

H. H. Turner, Esq., D.Sc., D.C.L., F.R.S., Savilian Professor of Astronomy, Oxford.

Council.

S. Chapman, Esq., M.A., D.Sc., F.R.S., Chief Professor of Mathematics, Imperial College of Science and Technology, South Kensington.
L. J. Comrie, Esq., M.A., Ph.D.
C. R. Davidson, Esq.
A. S. Eddington, Esq., M.A., D.Sc., LL.D., F.R.S., Plumian Professor of Astronomy, Cambridge.
Alfred Fowler, Esq., D.Sc., F.R.S., Yarrow Research Professor of the Royal Society, Imperial College of Science and Technology, South Kensington.
W. M. H. Greaves, Esq., M.A.
F. J. Hargreaves, Esq., F.C.I.P.A.
Harold Jeffreys, Esq., M.A., D.Sc., F.R.S.
Gerald Merton, Esq., M.C., M.A., Ph.D.
E. A. Milne, Esq., M.A., F.R.S., Rouse Ball Professor of Mathematics, Oxford.
W. M. Smart, Esq., M.A., D.Sc.
W. H. Steavenson, Esq.